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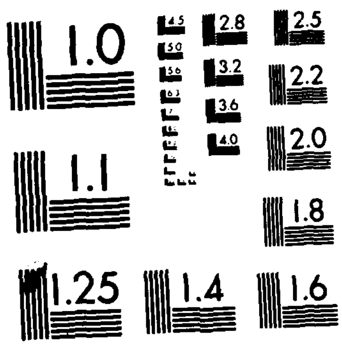

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A GENERALIZED ESCAPE SYSTEM SIMULATION (GESS) COMPUTER PROGRAM: GESS USER'S GUIDE VERSION II - VOLUME I

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The Generalized Escape System Simulation (GESS) program is a computerized mathematical model for dynamically simulating the performance of existing or developmental aircraft ejection seat systems. The program generates six-dimensional trajectory predictions of the aircraft, seat/occupant, occupant alone, and seat alone by calculating the forces and moments imposed on these elements by the seat catapults, rails, rockets, stabilization, and recovery systems included in most escape system configurations. User options

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are provided to simulate the performance of all conventional escape system designs under most environmental conditions and aircraft attitudes or trajectories. This GESS User's Guide describes the elements and events occurring in typical escape systems, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize this and the related ACT and DRAS programs. The GESS Programmer's Manual, a companion guide, lists the annotated FORTRAN-IV program code, and represents the second of two volumes of GESS documentation.

FOREWORD

This final report describes the elements and events occurring in a typical ejection with a state-of-the-art escape system, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize the Generalized Escape System Simulation (GESS) Computer Program and the related ACT and DRAS programs. The GESS Programmer's Manual, a companion guide, lists the annotated FORTRAN-IV program code and represents the second of two volumes of GESS documentation. A portion of this work was performed by Ketron, Inc., in accordance with NADC Contract N62269-81-C-0206, Task No. 630-1944.

This work was sponsored by the Naval Air Systems Command (AIR-5312) under Airtask No. A5315312-001D-1531W1100, Work Unit No. WC530.

ABSTRACT

The Generalized Escape System Simulation (GESS) program is a computerized mathematical model for dynamically simulating the performance of existing or developmental aircraft ejection seat systems. The program generates six-dimensional trajectory predictions of the aircraft, seat/occupant, occupant alone, and seat alone by calculating the forces and moments imposed on these elements by the seat catapults, rails, rockets, stabilization, and recovery systems included in most escape system configurations. User options are provided to simulate the performance of all conventional escape system designs under most environmental conditions and aircraft attitudes or trajectories. This *GESS User's Guide* describes the elements and events occurring in typical escape systems, the theory and formulation of the simulation model, and the procedures necessary to successfully prepare, execute, and utilize this and the related ACT and DRAS programs. The *GESS Programmer's Manual*, a companion guide, lists the annotated FORTRAN IV program code, and represents the second of two volumes of GESS documentation.

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1.0 INTRODUCTION

Designing ejection seat systems enabling the safe escape of crew-members from high-speed military aircraft is a formidable task. As an adjunct to the Navy's on-going escape systems program of system engineering, testing, and incident review, a mathematical model has been formulated and developed to simulate the operation of any ejection seat-based escape system under most realistic conditions from any aircraft. This User's Guide desc ,e the preparation and use of the Generalized Escape System Simulation .;S) program.

Originally in February 1972, the Naval Aerospace Recovery Facility, El Centro, contracted Vought Aeronautics Company to develop a simulation model of the SIIIS-3 (now SEU-3/A) Escape System, made by Stencel Aero Engineering Corporation(1)*. This program was a reformulation of an earlier program which Vought produced for the Air Force in 1970(2). This Navy program, named ICARUS(3) provided greater detail in the modeling of the individual system elements than did its predecessor. These enhancements allowed greater flexibility in studying hardware modifications and occupant physiological effects. The completed program provided engineers, civilian management, and Navy personnel with greater ability to:

- establish escape system performance requirements,
- evaluate competitive escape system proposals,
- evaluate escape system design modifications,
- monitor escape system test programs,
- prepare fleet information on escape systems, and
- investigate in-flight escape incidents.

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* All references may be found in Section 7.0.

The ICARUS program results were compared with test data, and then modified to achieve acceptable results[4,5].

In 1976, the ICARUS program was obtained by the Naval Air Development Center (NADC),Warminster, for use in the F-18 escape system development program. This effort required a substantial reprogramming of the model due to the incorporation of the Martin-Baker escape system in the F-18 aircraft. As this difficult task continued, it became clear that a more flexible model, which could be easily configured by the user to simulate a wide variety of escape systems and aircraft designs, was critically needed.

In 1980, NADC contracted the Computer Sciences Corporation to reformulate and code the simulation model which was to become known as GESS. This program, later revised and documented by KETRON, INC., provides the user with a greatly enhanced capability to describe escape system parameters without code modification, and to execute simulation runs with significantly improved computational efficiency. The capability to produce graphics output through the use of the DRAS program has also been added.

This *GESS User's Guide* is Volume I of two volumes of GESS documentation. Volume II is the *GESS Programmer's Manual*, which includes the annotated GESS program listing.

2.0 ESCAPE SYSTEM OPERATION

Following an aircraft failure requiring emergency egress, a typical sequence of escape system events could be:

(1) trigger mechanism initiation

(2) catapult(s) ignition

(3) seat first motion

(4) drogue gun/container deployment

(5) catapult(s) separation

(6) rail(s) separation

(7) rocket(s) ignition

(8) seat separation from aircraft

(9) stabilization system operation

(10) rocket(s) burnout

(11) recovery chute deployment

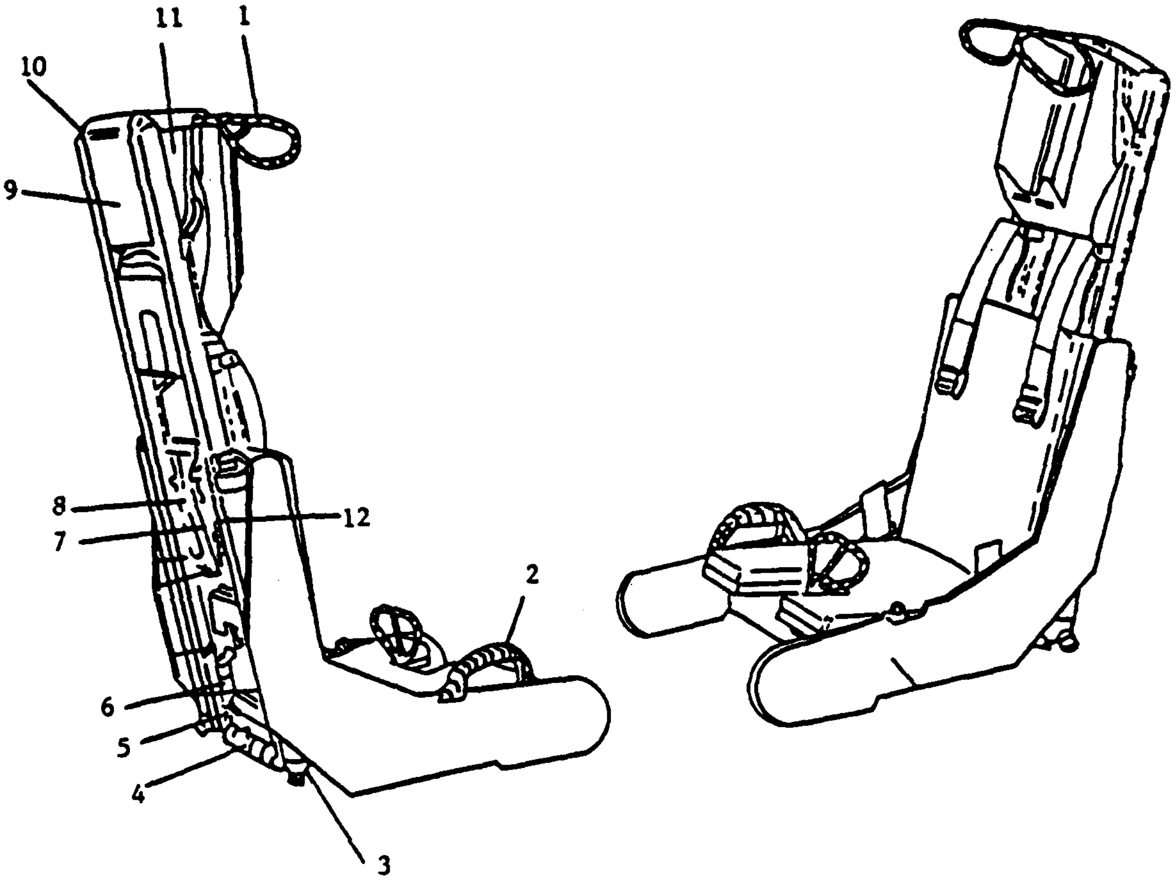
(12) recovery chute line stretch

(13) seat/occupant separation

(14) recovery chute full inflation

Although every supplier of escape systems incorporates somewhat different configurations and mechanisms for accomplishing these tasks, the general functional sequence includes most or all of these events.

The components of a typical ejection seat system are shown in Figure 2-1.



1 - FACE CURTAIN EJECTION HANDLE
2 - EMERGENCY RELEASE HANDLE
3 - SEAT BACK ROCKET (SBR)(2)
4 - CATAPULT CARTRIDGE
5 - CATAPULT OUTER TUBE/GUIDE RAIL
6 - TIME DELAY INITIATORS (2)
7 - WORD
8 - DROGUE BRIDLE
9 - DROGUE CONTAINER
10 - CANOPY BREAKER
11 - PARACHUTE CONTAINER/HEADREST
12 - ANEROIDS (2)

Figure 2-1. SIIIS-3 Escape System Components

Upon catapult ignition, pressure is rapidly created within the catapult tubes providing thrust to initiate seat motion along a prescribed path out of the aircraft. When the seat headbox enters the airstream, after either canopy jettison or penetration, the drogue parachute is deployed from the seat. Prior to or at the time of seat separation from the aircraft, the rockets located on the seat are ignited, providing additional thrust to move the seat and its occupant away from the aircraft.

As the seat continues its trajectory from the aircraft, it must be stabilized through the use of a system such as the Directional Automatic Realignment of Trajectory (DART) system. This system consists of a brake attached to the seat through which one or two aircraft-attached lines are played out, producing a moment designed to correct any adverse seat attitude. These lines break when the seat reaches a specific distance from the aircraft.

Deployment of the recovery system is usually accomplished either by a drogue parachute, a Wind Oriented Rocket Deployment (WORD) system, mortar deployment, or a combination of these. The time of deployment of the recovery system is controlled by the seat sequencing mechanism, which senses seat airspeed and altitude.

As the parachute deploys, the risers and suspension lines develop tension from the differential momentum between the inflating parachute canopy and the seat/occupant. This causes the seat and occupant to separate. The seat moves away from the occupant as the occupant/parachute system decelerates further under the action of the inflating parachute canopy.

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3.0 FORMULATION

3.1 Coordinate Systems

Trajectories generated by the Generalized Escape System Simulation (GESS) program are calculated with respect to specific, "right hand rule," coordinate systems coinciding with center of gravities or other specified reference points of the various system elements. Each of the program coordinate systems is defined by six (6) degrees of freedom:

A. Linear:

1. X - forward positive displacement
2. Y - left positive displacement
3. Z - upward positive displacement

B. Angular:

4. Yaw (R) - leftward positive rotation
5. Pitch (Q)- nose downward positive rotation
6. Roll (P) - right wing downward positive rotation

These coordinate systems, illustrated in Figure 3-1, are defined as follows:

- Earth-Fixed Coordinate System (EFCS)

The EFCS is a 3-axis orthogonal coordinate system with origin at a fixed point located on or near the surface of the earth. Since all simulated distances are relatively small compared to the earth's radius, the errors associated with neglecting the curvature of the earth's surface are considered negligible. The movements and rotations of all simulated system elements can be described with respect to (wrt) this fixed coordinate system.

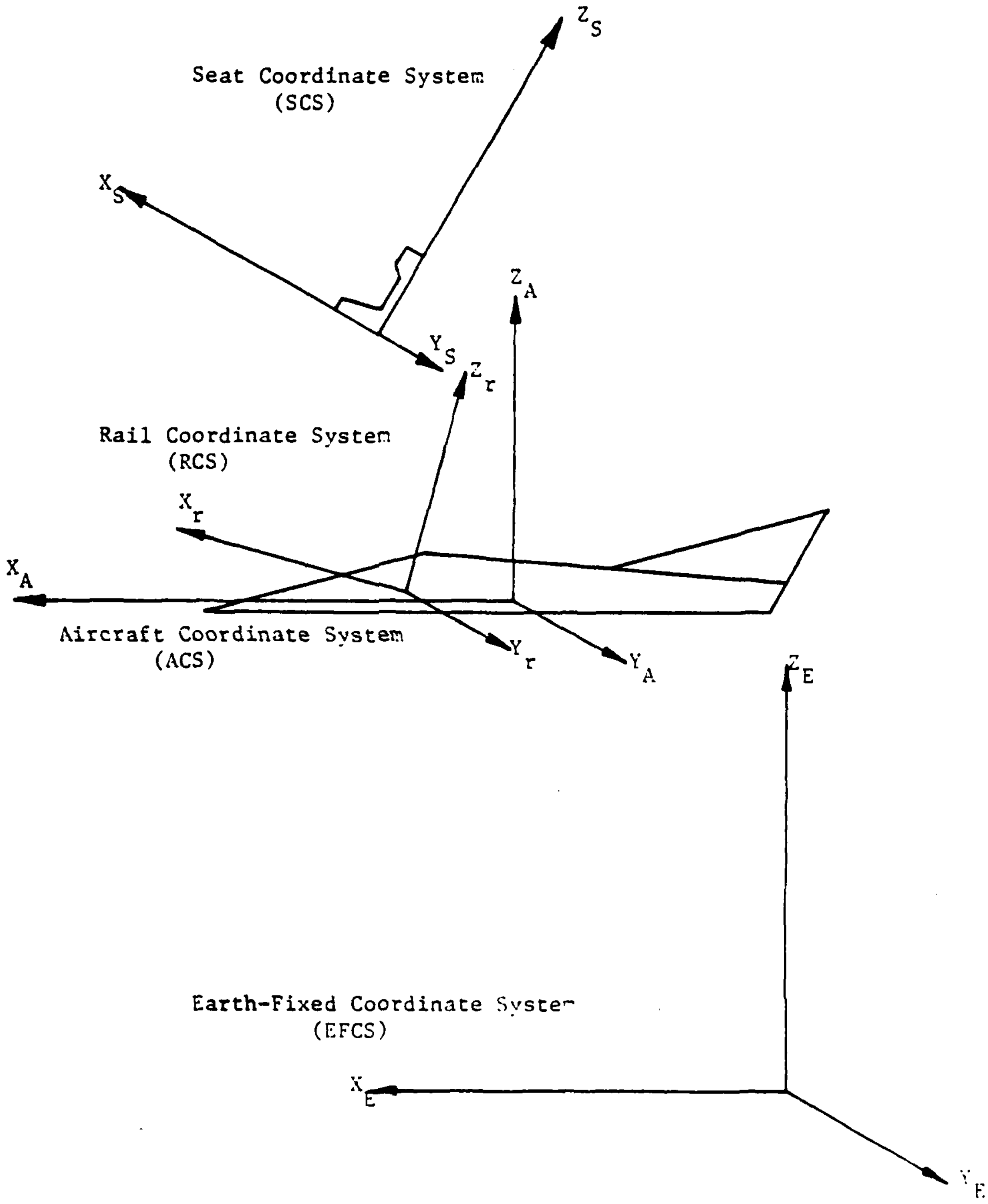


Figure 3-1. Coordinate Systems

- <u>Aircraft Coordinate System (ACS)</u>

The ACS is a 3-axis orthogonal coordinate system with origin at a fixed point, usually the aircraft's center of gravity. All linear and angular movements of the aircraft are determined by establishing the position of this coordinate system wrt the EFCS. The position of all other system elements, prior to and, optionally, after the separation of the seat from the aircraft, is determined wrt to the ACS.

- <u>Rail Coordinate System (RCS)</u>

The RCS is a 3-axis orthogonal coordinate system which is defined and fixed wrt the ACS. Its origin coincides with the mid-point between the rails of the lateral (Y) axis defined by the two lowest rail points in the ACS, and its vertical (Z) axis is parallel to the rails. The rail system serves to restrict the motion of the seat to a specific path as it moves out of the aircraft cockpit.

- <u>Seat Coordinate System (SCS)</u>

The SCS is a 3-axis orthogonal coordinate system with origin usually corresponding to the initial location of the RCS origin wrt the seat. The center of gravity (CG) of either the seat/occupant (S/O) combination or the seat/alone (S/A) is referenced wrt the SCS, allowing the trajectories of these system elements to be tracked wrt either the ACS or the EFCS. Points of application of the various forces acting on the S/O or S/A are also referenced wrt the SCS, allowing the calculation of moments and rotation around the respective CGs.

- Occupant Alone Coordinate System (OACS)

The OACS is a 3-axis orthogonal coordinate system with origin at the center of gravity of the seat occupant after the occupant separates from the seat. The OACS is currently defined only by the three linear degrees of freedom because the disjointed non-rigidity of the occupant alone makes any angular determination difficult, if not irrelevant. Provisions have been made for the future incorporation of OACS angular degrees of freedom if such information is necessary at a later date.

- Thrust Vector Control Coordinate System (TVCCS)

The TVCCS is a 3-axis orthogonal coordinate system with origin at the common intersection of the rocket line of thrust and the centerlines of its gimbals. This coordinate system establishes the orientation of the rocket line of thrust, which is modified dynamically as part of the vertical-seeking maneuver.

Coordinate systems and vector directions should be carefully considered when preparing simulation inputs. All output reports are referenced accordingly.

3.1.2 Notation and Variable Identification. For brevity, vector notation is used in the formulation wherever possible. Individual component equations are occasionally used for clarity. Position vectors are denoted by the symbol $\vec{r}$. Hence, $\vec{r}_{ASO}$ represents the position vector from the aircraft CG to the seat/occupant CG, while $\vec{r}_{SA}$ represents the position vector of the seat alone with respect to the EFCS. Direction cosine matrices are denoted by the symbol D_{ij}. Hence, D_{AE} represents the direction cosine matrix which transforms components of a vector presented in the AFCS to components presented in the EFCS.

Several naming conventions are used to identify variables used in the formulation. Refer to Section 4.0 for specific variable descriptions. These naming conventions are summarized below.

SA	-	seat alone
OA	-	occupant alone
SO	-	seat/occupant
NPTS	-	number of points
RK	-	rocket
WGHT	-	weight
X	-	X axis
Y	-	Y axis
Z	-	Z axis
P	-	roll rotation
Q	-	pitch rotation
R	-	yaw rotation
VEL	-	velocity
PORO	-	porosity
REC	-	recovery parachute

DRO/DR - drogue parachute

DRT - DART

POS - position

IGN - ignition

CAT - catapult

TVC - thrust vector control

CG - center of gravity

The variable names used in the formulation have been selected to facilitate the user's understanding. There is limited correlation between these variable names and the coded variable names used in the actual program.

3.1.3. Units of Measure. Either English or metric units of measure may be used in the GESS program. The specific units required for either system of measure selected by the user are detailed for each input variable in Section 4.0. No units of measure are referenced in the formulation.

3.2 Vector Mathematics

3.2.1 Position Vectors. A position vector is a representation of the location of a specified external point, with reference to a stated initial point, characterized by both distance or magnitude and direction components. By stating the location of a point, denoted (2), in terms of the origin of a specified coordinate axis (1), the position vector ($\vec{r}_{12}$) from the origin of the coordinate system to the point is defined. The calculation of the position vector $\vec{r}_{23}$, between the two points, (2) and (3), is facilitated by vector subtraction. These principles are illustrated in Figure 3-2.

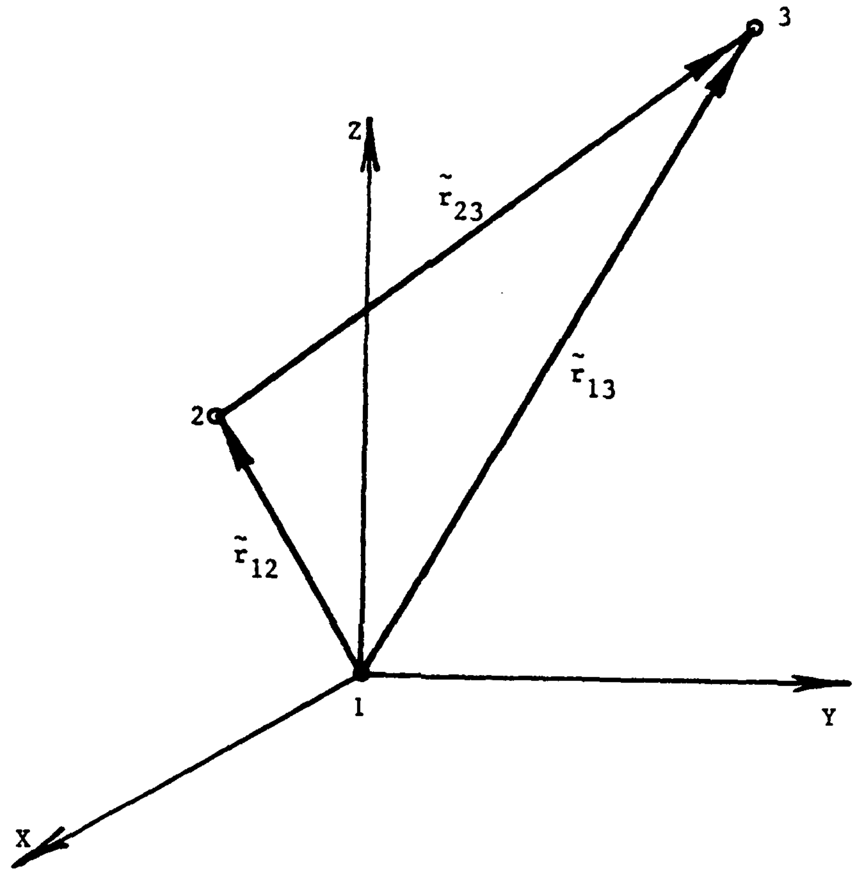


Figure 3-2. Generalized Position Vectors

The definitions of the position vectors used in GESS are given in conjunction with discussions of the formulation in which they are used.

3.2.2 Direction Cosine Matrices. Direction cosine matrices (DCMs) are used to transpose position vectors from one coordinate system to the orientation of another coordinate system. Such transformations are necessary prior to vector addition or subtraction operations intended to determine resultant vectors. Hence, the addition of the position vectors $\vec{r}_{12}$ and $\vec{r}_{23}$ will yield the new position vector $\vec{r}_{13}$ after $\vec{r}_{23}$ has been transposed into the $\vec{r}_{12}$ coordinate system. Further, given position vectors $\vec{r}_{12}$ and $\vec{r}_{34}$, the vector $\vec{r}_{24}$ can be found by subtracting $\vec{r}_{12}$ from the addition of $\vec{r}_{13}$ and the transposition of $\vec{r}_{34}$ into the $\vec{r}_{12}$ coordinate system. These principles are illustrated in Figures 3-3 and 3-4.

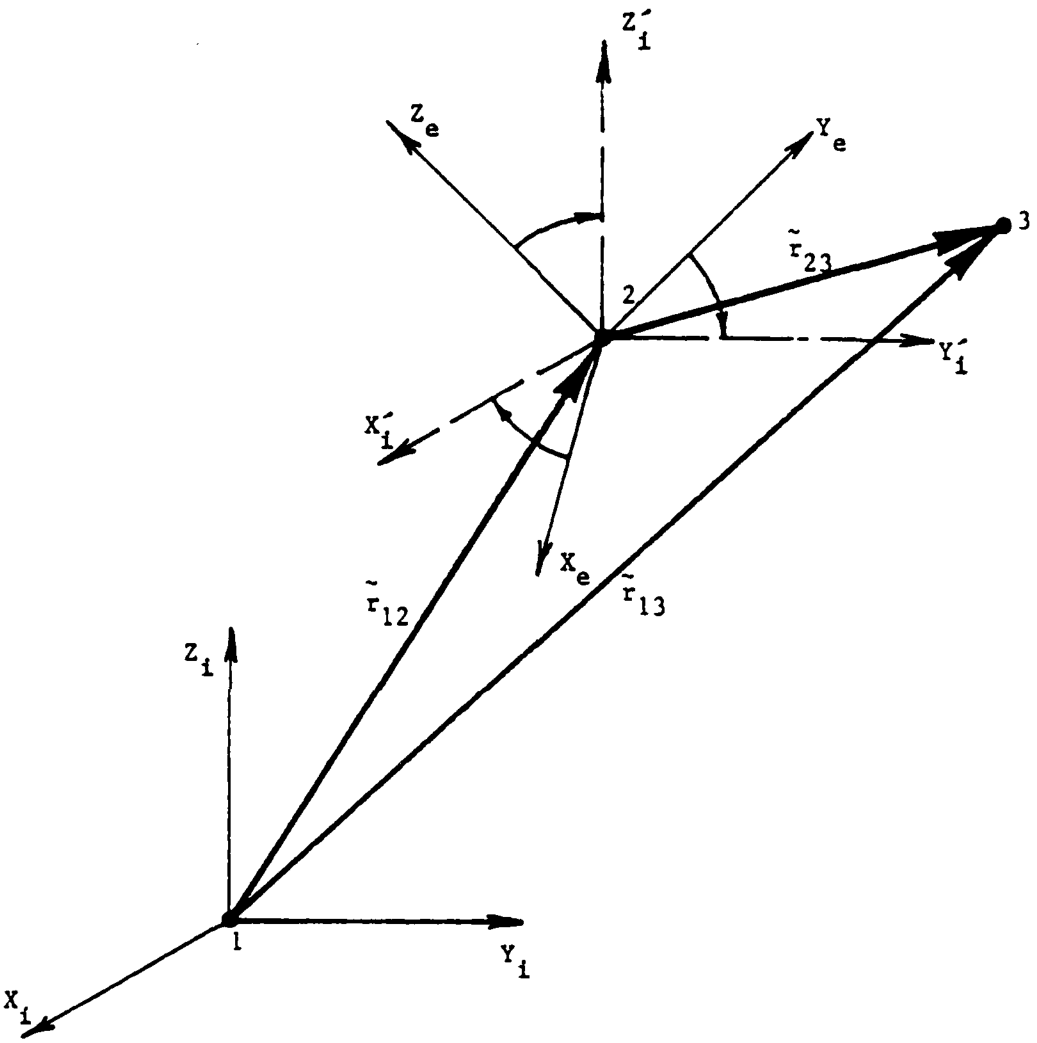


Figure 3-3. Vector Addition Using Transformation

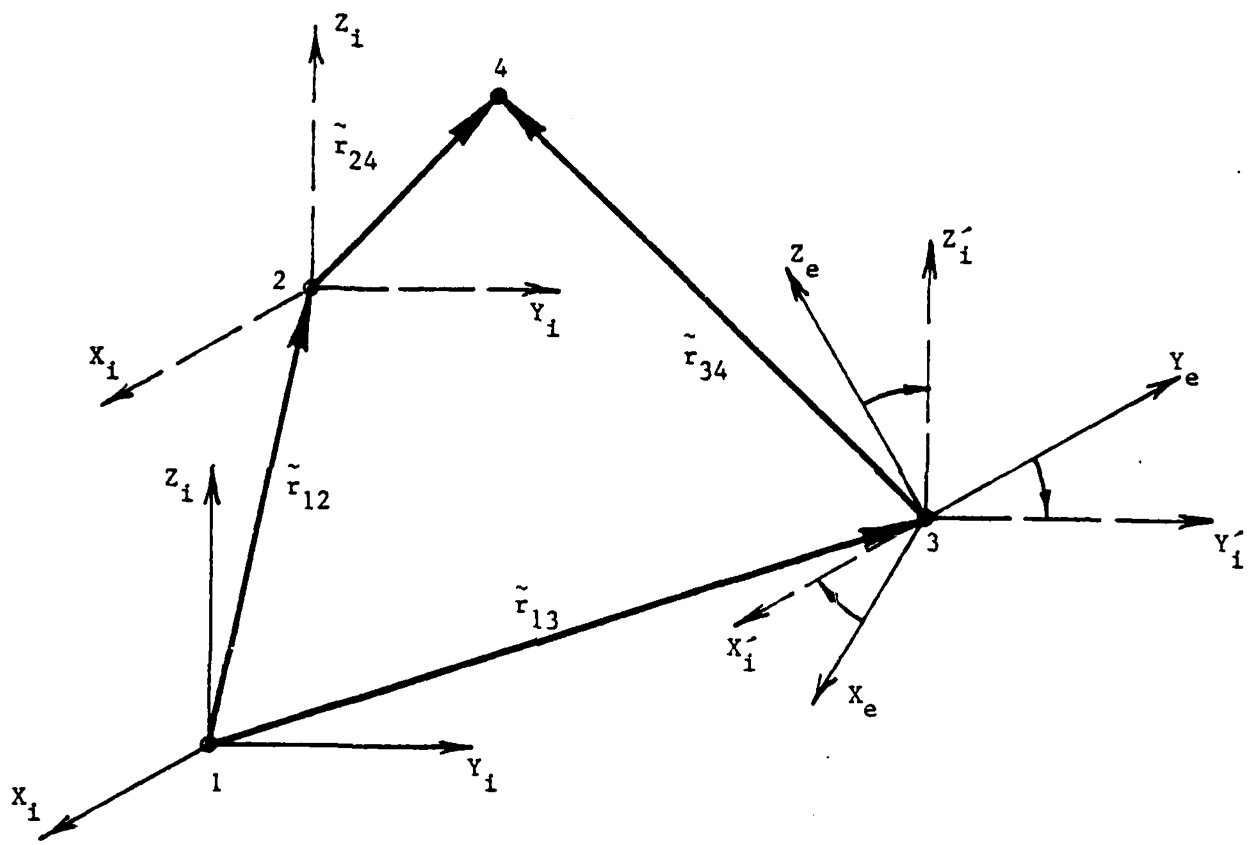


Figure 3-4. Vector Subtraction Using Transformation

The generalized DCM, D_{21}, which transforms a vector in the initial coordinate system to the coordinates of an external coordinate system is given by:

$$D_{21} = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix} \qquad (1)$$

where:

$$d_{11} = \cos\beta \cos\gamma \qquad (1.a)$$

$$d_{12} = \cos\beta \sin\gamma \qquad (1.b)$$

$$d_{13} = -\sin\beta \qquad (1.c)$$

$$d_{21} = -\sin\gamma \cos\alpha + \sin\alpha \sin\beta \cos\gamma \qquad (1.d)$$

$$d_{22} = \cos\gamma \cos\alpha + \sin\alpha \sin\beta \sin\gamma \qquad (1.e)$$

$$d_{23} = \cos\beta \sin\alpha \qquad (1.f)$$

$$d_{31} = \sin\alpha \sin\gamma + \sin\beta \cos\alpha \cos\gamma \qquad (1.g)$$

$$d_{32} = -\sin\alpha \cos\gamma + \sin\beta \cos\alpha \sin\gamma \qquad (1.h)$$

$$d_{33} = \cos\alpha \cos\beta \qquad (1.i)$$

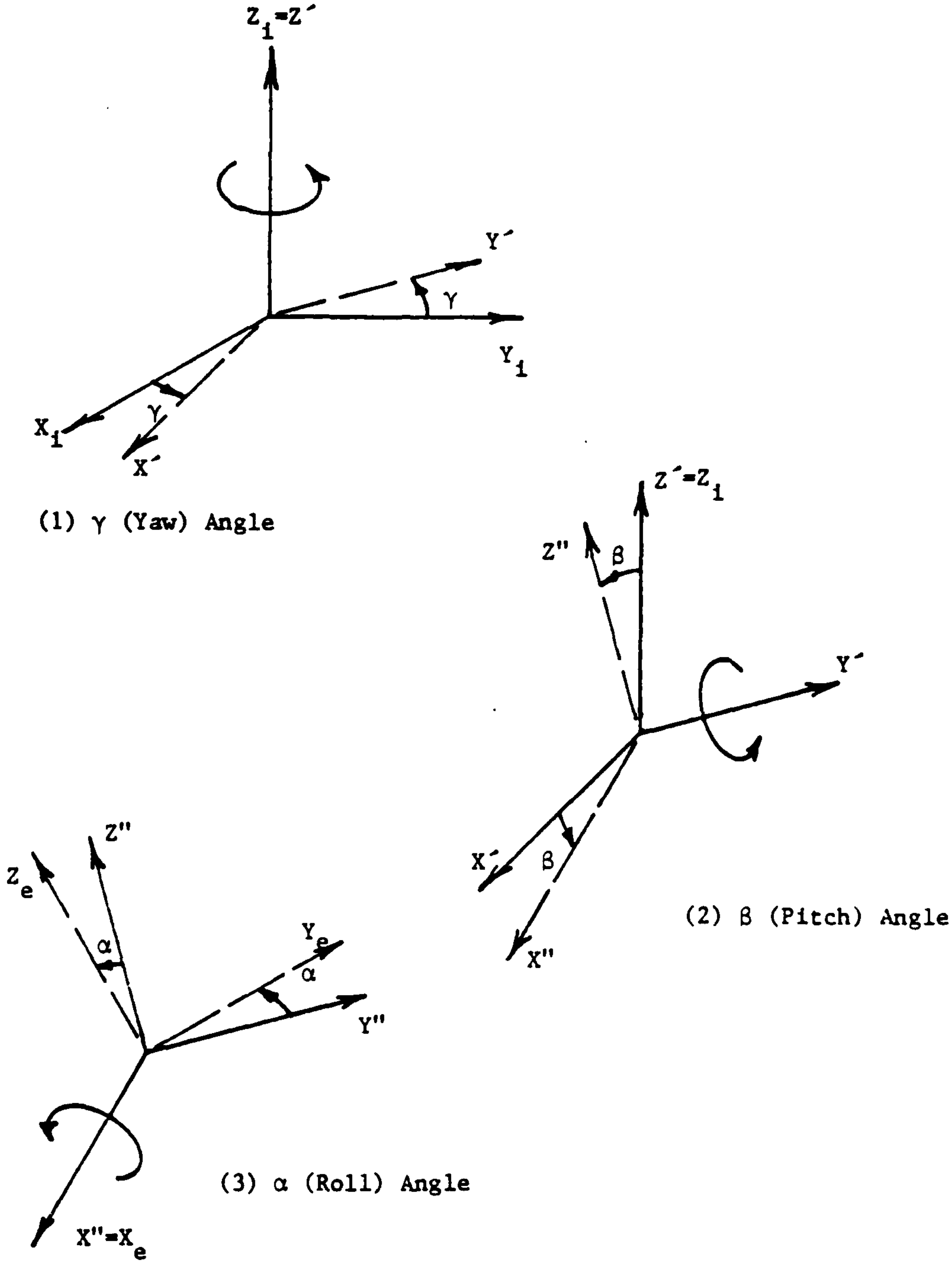
and where the modified Euler angles are:

$\alpha \equiv$ positive rotation to right about the X" axis (Roll)

$\beta \equiv$ positive rotation nose downward about the Y' axis (Pitch)

$\gamma \equiv$ positive rotation to left about the Z_1 axis (Yaw)

These angles are illustrated in Figure 3-5.



(1) γ (Yaw) Angle

(2) β (Pitch) Angle

(3) α (Roll) Angle

Figure 3-5. Modified Euler Angles For Direction Cosine Matrices

Thus, the position vector resulting from the addition of the position vector to the external coordinate system origin to a position vector in that external coordinate system, as in Figure 3-3, is given by:

$$\bar{r}_{13} = \bar{r}_{12} + D_{21} \; \bar{r}_{23}$$

And, the position vector found by subtracting two separately coordinated position vectors, as in Figure 3-4, is given by:

$$\bar{r}_{24} = \bar{r}_{13} + D_{21} \; \bar{r}_{34} - \bar{r}_{12}$$

A final principle involves the use of the transpose of the DCM, which is defined as:

$$D_{21}^{T} = \begin{bmatrix} d_{11} & d_{21} & d_{31} \\ d_{12} & d_{22} & d_{32} \\ d_{13} & d_{23} & d_{33} \end{bmatrix} = D_{12} \qquad (2)$$

If the DCM which transforms the first coordinate system into the second is used, then Figure 3-3 can be represented as:

$$\bar{r}_{13} = \bar{r}_{23} + D_{21}^{T} \; \bar{r}_{12}$$

and Figure 3-4 is represented as:

$$\bar{r}_{24} = \bar{r}_{31} + D_{21}^{T} \; \bar{r}_{12} - \bar{r}_{34}$$

This is possible since all DCMs are orthogonal matrices; for this class of matrices, $D_{21}^{T} = D_{21}^{-1}$, where: $D_{21}^{-1} \equiv$ inverse of D_{21}. Thus, a single DCM is used to enable position vector transformation in either direction between two separate coordinate systems.

The definitions of the specific modified Euler angles describing the relative orientations of the various program coordinate systems, and their respective DCMs, are described in conjunction with the discussion of the formulation in which they are used.

3.2.3 Quaternions. Calculating the components of the DCMs for each of the coordinate system pairs using the modified Euler angles involves a considerable use of trigonometric functions. The cost of using these functions, in terms of computer time and CPU memory, is excessive in a large iterative program. This problem has been substantially resolved in GESS through the use of unit quaternions.

Quaternions are represented symbolically as the sum of a vector and a scalar, and may be interpreted geometrically by considering them as operators on vectors. In GESS, unit quaternions are used to update DCMs during integration of each system element's equations of motion. During program initiation, quaternion components are initiated for each DCM as:

$$\lambda_o = (1/2)[|(1 + d_{11} + d_{22} + d_{33})|]^{1/2} \quad (3.a)$$

$$\lambda_1 = (d_{23} - d_{32})/4\lambda_o \quad (3.b)$$

$$\lambda_2 = (d_{31} - d_{13})/4\lambda_o \quad (3.c)$$

$$\lambda_3 = (d_{12} - d_{21})/4\lambda_o \quad (3.d)$$

where the DCM components indicated have been initialized by the trigonometric calculations used in equation (1).

Following initiation, the quaternion is updated during every integration time step by the matrix differential equation:

$$\begin{bmatrix} \dot{\lambda}_o \\ \dot{\lambda}_1 \\ \dot{\lambda}_2 \\ \dot{\lambda}_3 \end{bmatrix} = \begin{bmatrix} 0 & p & q & r \\ -p & 0 & -r & q \\ -q & r & 0 & -p \\ -r & -q & p & 0 \end{bmatrix} \begin{bmatrix} \lambda_o \\ \lambda 1 \\ \lambda 2 \\ \lambda 3 \end{bmatrix} \quad (4)$$

where:

$p \equiv$ angular velocity of roll angle, α

$q \equiv$ angular velocity of pitch angle, β

$r \equiv$ angular velocity of yaw angle, γ

The new orientation of the system element with respect to the DCM reference coordinate system is then obtained by integrating:

$$\lambda_i = \int \dot{\lambda}_i dt \qquad (i = 0,1,2,3) \tag{5}$$

And, the new DCM, D_{21}' is found from:

$$D_{21}' = \begin{bmatrix} d_{11}' & d_{12}' & d_{13}' \\ d_{21}' & d_{22}' & d_{23}' \\ d_{31}' & d_{32}' & d_{33}' \end{bmatrix} \tag{6}$$

where

$$d_{11}' = 2(\lambda_0^2 + \lambda_1^2)-1 \tag{6.a}$$

$$d_{12}' = 2(\lambda_1\lambda_2 + \lambda_0\lambda_3) \tag{6.b}$$

$$d_{13}' = 2(\lambda_1\lambda_3 - \lambda_0\lambda_2) \tag{6.c}$$

$$d_{21}' = 2(\lambda_1\lambda_2 - \lambda_0\lambda_3) \tag{6.d}$$

$$d_{22}' = 2(\lambda_0^2 + \lambda_2^2)-1 \tag{6.e}$$

$$d_{23}' = 2(\lambda_2\lambda_3 + \lambda_0\lambda_1) \tag{6.f}$$

$$d_{31}' = 2(\lambda_1\lambda_3 + \lambda_0\lambda_2) \tag{6.g}$$

$$d_{32}' = 2(\lambda_2\lambda_3 - \lambda_0\lambda_1) \tag{6.h}$$

$$d_{33}' = 2(\lambda_0^2 + \lambda_3^2)-1 \tag{6.i}$$

Finally, the new modified Euler angles can be found from:

$$\alpha' = \tan^{-1} (d'_{23}/d'_{33}) \tag{7.a}$$

$$\beta' = \sin^{-1} (d'_{13}) \tag{7.b}$$

$$\gamma' = \tan^{-1} (d'_{12}/d'_{11}) \tag{7.c}$$

A more detailed discussion of the theory and use of quaternions can be found in most linear algebra texts.

3.3 Equations of Motion

3.3.1 Aircraft. The aircraft equations of motion are based upon linear and angular input values of position, velocity, and acceleration for each of six degrees of freedom with respect to the EFCS. No external forces, such as gravity, thrust, or moments are considered, although the linear and angular acceleration input can be structured as a function of time to represent nearly any aircraft maneuver. The input values are then integrated over the simulation time increment to determine the linear and angular time history of the aircraft with respect to the earth.

The aircraft equations of motions are:

$$\tilde{s}_{AC} = \int \dot{\tilde{s}}_{AC} dt \tag{8.a}$$

$$\tilde{v}_{AC} = \int \dot{\tilde{v}}_{AC} dt \tag{8.b}$$

$$\tilde{\Theta}_{AC} = \int \dot{\tilde{\Theta}}_{AC} dt \tag{8.c}$$

$$\tilde{\omega}_{AC} = \int \dot{\tilde{\omega}}_{AC} dt \tag{8.d}$$

where:

$\tilde{s}_{AC}$ ≡ linear displacement vector wrt EFCS

$\tilde{v}_{AC}$ ≡ linear velocity vector wrt EFCS

$\tilde{\Theta}_{AC}$ ≡ angular displacement vector wrt EFCS

$\tilde{\omega}_{AC}$ ≡ angular velocity vector wrt EFCS

3.3.2 Seat/Occupant and Seat Alone. Both the seat/occupant and seat alone configurations are considered as rigid bodies. Consequently, the equations of motion for both of these configurations are given by:

$$m_s \left(\dot{\tilde{V}}_s + \tilde{\omega}_s \times \tilde{V}_s\right) = \Sigma \tilde{F}_s \tag{9.a}$$

and

$$[I_s]\,\dot{\tilde{\omega}}_s + \tilde{\omega}_s \times [I_s]\tilde{\omega}_s = \Sigma \tilde{M}_s \tag{9.b}$$

where:

$\Sigma \tilde{F}_s$ ≡ summation of the external forces acting on the S/O or S/A

$\Sigma \tilde{M}_s$ ≡ summation of the external moments acting on the S/O or S/A

m_s ≡ mass of the S/O or S/A

$[I_s]$ ≡ moment of inertia matrix for the S/O or S/A

$\dot{\tilde{V}}_s$ ≡ linear acceleration vector for the S/O or S/A

$\tilde{V}_s$ ≡ linear velocity vector for the S/O or S/A

$\tilde{\omega}_s$ ≡ angular velocity vector for the S/O or S/A

$\dot{\tilde{\omega}}_s$ ≡ angular acceleration vector for the S/O or S/A

The possible external forces acting on the S/O are given by:

$$\Sigma \tilde{F}_{so} = \tilde{F}_c + \tilde{F}_R + \tilde{F}_r + \tilde{F}_A + \tilde{F}_D + \tilde{F}_{DC} + \tilde{F}_{RC} + \tilde{F}_g \qquad (10.a)$$

where:

$\tilde{F}_c \equiv$ catapult forces

$\tilde{F}_R \equiv$ rocket forces

$\tilde{F}_r \equiv$ rail forces

$\tilde{F}_A \equiv$ aerodynamic forces

$\tilde{F}_D \equiv$ DART forces

$\tilde{F}_{DC} \equiv$ drogue parachute forces

$\tilde{F}_{RC} \equiv$ recovery parachute forces

$\tilde{F}_g \equiv$ gravitational forces

The possible external moments acting on the S/O are:

$$\Sigma \tilde{M}_{so} = \tilde{M}_c + \tilde{M}_R + \tilde{M}_r + \tilde{M}_A + \tilde{M}_D + \tilde{M}_{DC} + \tilde{M}_{RC} \qquad (10.b)$$

where:

$\tilde{M}_c \equiv$ catapult moments

$\tilde{M}_R \equiv$ rocket moments

$\tilde{M}_r \equiv$ rail moments

$\tilde{M}_A \equiv$ aerodynamic moments

$\tilde{M}_D \equiv$ DART moments

$\tilde{M}_{DC} \equiv$ drogue parachute moments

$\tilde{M}_{RC} \equiv$ recovery parachute moments

The external forces and moments acting on the S/A are:

$$\Sigma\tilde{F}_{SA} = \tilde{F}_A + \tilde{F}_g \tag{11.a}$$

$$\Sigma\tilde{M}_{SA} = \tilde{M}_A \tag{11.b}$$

The new positions and orientations of the S/O or S/A with respect to the EFCS are obtained by integrating twelve (12) differential equations. These equations are:

$$u_s = \int \dot{u}_s dt \tag{12.a}$$

$$v_s = \int \dot{v}_s dt \tag{12.b}$$

$$w_s = \int \dot{w}_s dt \tag{12.c}$$

$$x_s = \int \dot{x}_s dt \tag{12.d}$$

$$y_s = \int \dot{y}_s dt \tag{12.e}$$

$$z_s = \int \dot{z}_s dt \tag{12.f}$$

$$p_s = \int \dot{p}_s dt \tag{12.g}$$

$$q_s = \int \dot{q}_s dt \tag{12.h}$$

$$r_s = \int \dot{r}_s dt \tag{12.i}$$

$$\dot{p}_s = \int \ddot{p}_s dt \tag{12.j}$$

$$\dot{q}_s = \int \ddot{q}_s dt \tag{12.k}$$

$$\dot{r}_s = \int \ddot{r}_s dt \tag{12.l}$$

where:

$$\begin{bmatrix} \dot{x}_s \\ \dot{y}_s \\ \dot{z}_s \end{bmatrix} = [D_{SE}]^T \begin{bmatrix} u_s \\ v_s \\ w_s \end{bmatrix} \tag{13}$$

It should be noted that all u, v, w, $\dot{p}$, $\dot{q}$, and $\dot{r}$ terms refer to the SCS, while the x, y, z, p, q and r terms refer to the EFCS.

3.3.3 Occupant Alone. The occupant alone (O/A) configuration cannot be considered as a rigid body because of the numerous degrees of freedom of the various body elements. Consequently, any singular consideration of angular orientation, velocity, or acceleration is meaningless. Therefore, the equation of motion for the O/A is based on only the three (3) linear degrees of freedom, and is given by:

$$m_{OA}\dot{\tilde{V}}_{OA} = \Sigma\tilde{F}_{OA} \tag{14}$$

where:

m_{OA} ≡ mass of the O/A

$\dot{\tilde{V}}_{OA}$ ≡ linear acceleration vector of the O/A

$\Sigma\tilde{F}_{OA}$ ≡ summation of the external force vector acting on the O/A

The external forces acting on the O/A are:

$$\Sigma\tilde{F}_{OA} = \tilde{F}_{RC} + \tilde{F}_{A} + \tilde{F}_{g} \tag{15}$$

The new position of the O/A with respect to the EFCS is obtained by integrating the same twelve (12) equations as the S/O and S/A (equations 12.a-l). However, all angular terms are set equal to zero. This causes the DCM to be a unity matrix, and there is no relevant distinction between the OACS and EFCS position and velocity terms. These equations become:

$$u_{OA} = \int \dot{u}_{OA} dt \tag{15.a}$$

$$v_{OA} = \int \dot{v}_{OA} dt \tag{15.b}$$

$$w_{OA} = \int \dot{w}_{OA} dt \tag{15.c}$$

$$x_{OA} = \int \dot{x}_{OA} dt \tag{15.d}$$

$$y_{OA} = \int \dot{y}_{OA} dt \tag{15.e}$$

$$z_{OA} = \int \dot{z}_{OA} dt \tag{15.f}$$

$$p_{OA} = 0 \tag{15.g}$$

$$q_{OA} = 0 \tag{15.h}$$

$$r_{OA} = 0 \tag{15.i}$$

$$\dot{p}_{OA} = 0 \tag{15.j}$$

$$\dot{q}_{OA} = 0 \tag{15.k}$$

$$\dot{r}_{OA} = 0 \tag{15.l}$$

3.4 Forces and Moments

The various forces and moments acting on the individual system elements result in changes to the trajectories of these elements. These forces and moments are dependent upon a wide variety of independent variables, and will be separately discussed in association with their sources.

3.4.1 Aircraft.

Prior to the unlocking of the catapult tubes at ejection initiation, the seat/occupant (S/O) is located by a fixed position vector from the aircraft center of gravity (CG). Thus, the forces and moments created by the aircraft's trajectory are directly translated to the S/O. However, since these forces and moments do not affect the S/O trajectory relative to the aircraft, the GESS program translates the aircraft accelerations and velocities directly to the S/O, but does not calculate specific forces and moments exerted on the S/O by the aircraft. The linear and angular aircraft accelerations in the ACS are entered as input time tables (refer to Sections 4.3.4.1. and 4.3.4.2.), allowing the user to simulate the forces and moments of any aircraft maneuver (also refer to Section 3.3.1).

3.4.2 Catapults and Catapult Tube. The GESS program allows the simulation of either one or two seat catapults. Input variables allow the seat-to-catapult moment arm vector(s), $\tilde{r}_{SCi}$, to be specified according to seat geometry. If two catapults are specified, the right (i = 1) and left (i = 2) catapult thrust time histories are input and tabulated separately to allow greater flexibility in simulating catapult system anomalies. The input catapult thrust versus time tables are linearly interpolated to determine thrust magnitudes between intermediate time points.

In the RCS, the right, left, and total catapult thrust vectors ($\tilde{F}_{C1}$, $\tilde{F}_{C2}$, and $\tilde{F}_C$, respectively) are given by:

$$\tilde{F}_{C1} = (0,0,T_{C1})^T \tag{16.a}$$

$$\tilde{F}_{C2} = (0,0,T_{C2})^T \tag{16.b}$$

$$\tilde{F}_C = \tilde{F}_{C1} + \tilde{F}_{C2} \tag{16.c}$$

where T_{C1} and T_{C2} are the right and left thrust table values, respectively.

The corresponding catapult moment vector, $\tilde{M}_C$, is formed to be:

$$\tilde{M}_C = \tilde{r}_{SC1} \times \tilde{F}_{C1} + \tilde{r}_{SC2} \times \tilde{F}_{C2} \tag{16.d}$$

where: $\tilde{r}_{SCi} \equiv$ vector moment arm from catapult i line of thrust to S/O CG

Figure 3-6 illustrates the forces and moments on the seat/occupant due to catapult thrust.

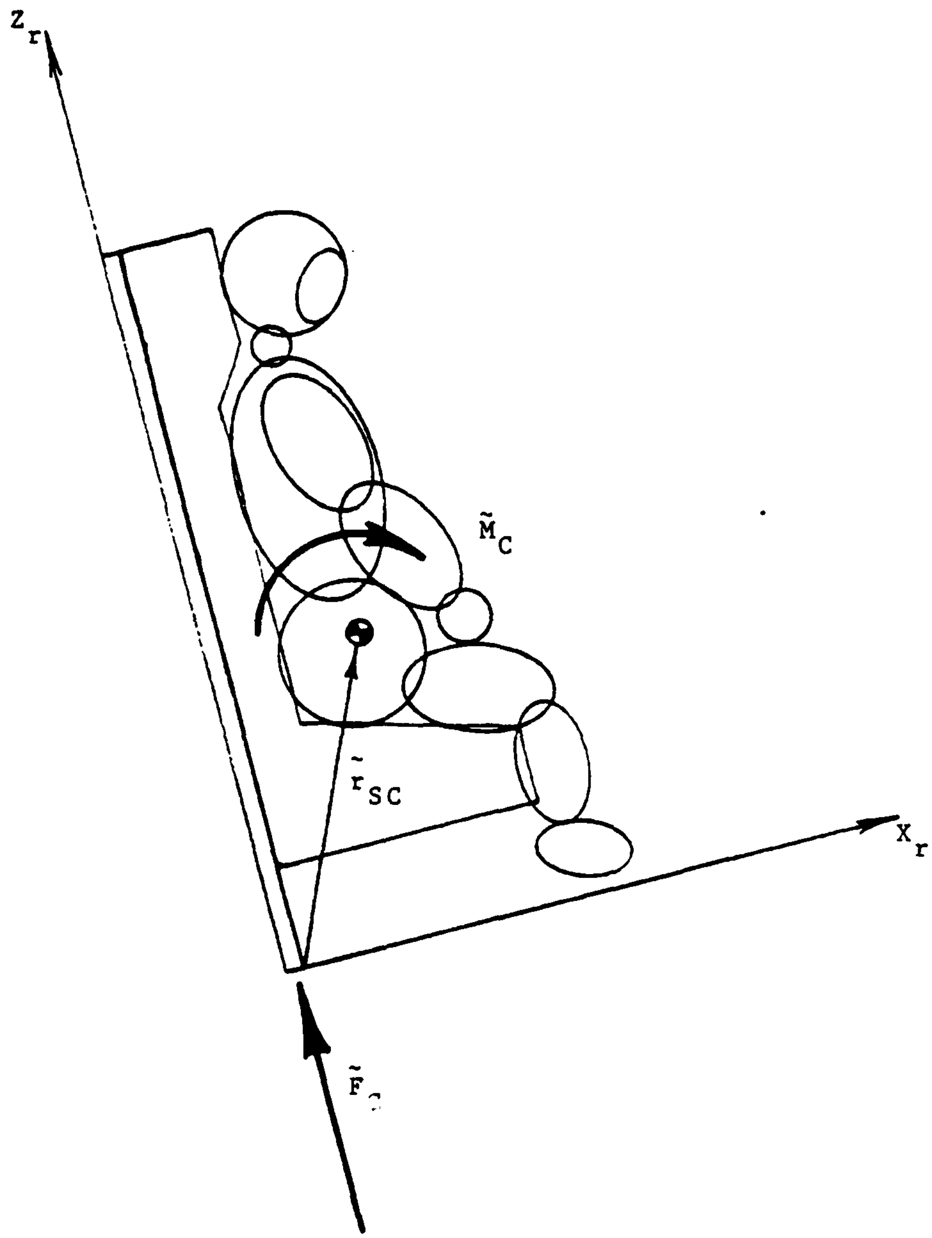


Figure 3-6. Catapult Forces and Moments

An additional force and moment source sometimes encountered in ejection seat systems is that of the bending catapult tube. As the seat moves out of the cockpit, it will, in some designs, remain attached to a single extended catapult tube until the tube extension length has been achieved. As the extension of the tube progresses, the aerodynamic forces acting on the seat/occupant cause the tube to deflect. This deflection results in a countering force on the S/O. Figure 3-7 illustrates the tube bending forces and moments.

In the RCS, the bending length, L_b, is found from:

$$L_b = [(\Delta X)^2 + (\Delta Y)^2 + (\Delta Z - L_i)^2]^{1/2} \qquad (17.a)$$

where:

ΔX ≡ change in X-axis position of catapult tube end

ΔY ≡ change in Y-axis position of catapult tube end

ΔZ ≡ change in Z-axis position of catapult tube end

L_i ≡ initial catapult length

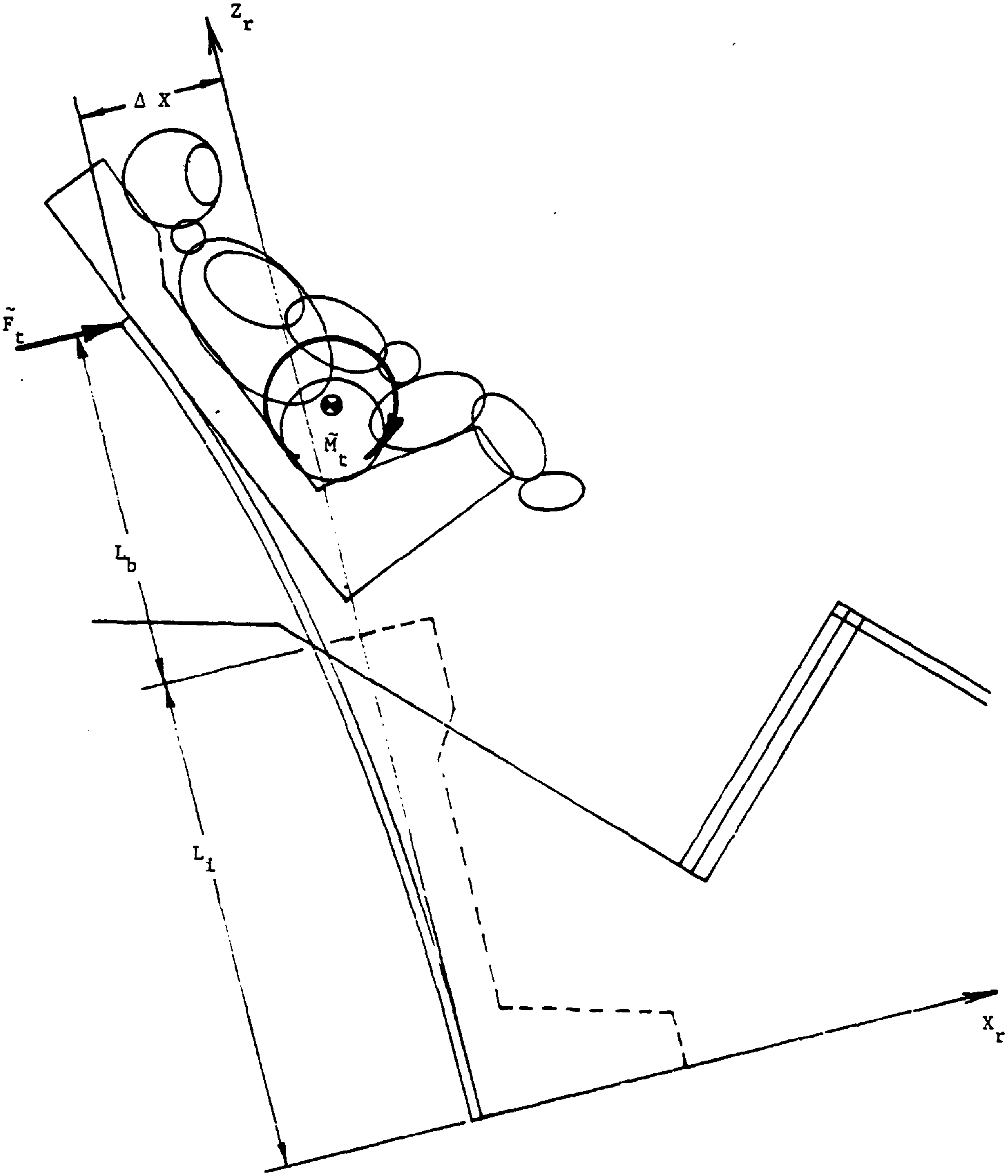


Figure 3-7. Catapult Tube Bending Forces and Moments

The catapult tube deflection, δ, is found from:

$$\delta = [(\Delta X)^2 + (\Delta Y)^2]^{1/2} \tag{17.b}$$

The total tube bending force, F_t, exerted on the S/O is:

$$F_t = K_t \, \delta \left(1 - \frac{L_b}{L_{mx}}\right)^2 \tag{18}$$

where:

K_t ≡ catapult tube stiffness constant

L_{mx} ≡ maximum catapult tube extension length

This yields the orthogonal force components:

$$F_{tx} = -F_t \Delta X/\delta \tag{19.a}$$

$$F_{ty} = -F_t \Delta Y/\delta \tag{19.b}$$

$$F_{tz} = -\mu_t F_t \tag{19.c}$$

where:

μ_t ≡ catapult tube friction coefficient

And, the corresponding tube bending moments are:

$$\tilde{M}_t = \tilde{F}_t \times \tilde{r}_{SC} \tag{20}$$

where:

$\tilde{r}_{SC}$ ≡ position vector from S/O CG to catapult attachment point

3.4.3 Sustainer Rockets. The sustainer rocket thrusts are handled similarly to the catapult thrusts in that each of up to six rockets have separate data inputs and thrust vs time tables, and are computed separately within the program. The multiple inputs may be used to investigate sustainer rocket anomalies or intentionally introduced asymmetry to achieve divergence in multi-seat aircraft. The unit vectors for each rocket's line of thrust, as seen in the SCS, are given by:

$$\tilde{U}_{Ri} = (\cos \alpha_{Ri}, \cos \beta_{Ri}, \cos \gamma_{Ri})^T, \qquad (i = 1 \text{ to } n, n < 6)$$

Figure 3-8 illustrates the modified Euler angles specifying the rocket thrust line orientation with respect to the RCS, and the unit vector components in the SCS.

The sustainer rocket thrust vector, F_R, in the SCS is given by:

$$\tilde{F}_R = \sum_{i=1}^{n} T_{Ri}\tilde{U}_{Ri}, \qquad (n < 6) \tag{21}$$

where:

T_{Ri} ≡ rocket i total thrust.

The corresponding rocket moments are:

$$\tilde{M}_R = \sum_{i=1}^{n}(\tilde{r}_{Ri} \times T_{Ri}\tilde{U}_{Ri}), \quad (n < 6) \tag{22}$$

The effect of rocket fuel burnoff on the S/O mass, m_{SO}, is computed as a linear function of rocket i burn time, Θ_{RBi}, from:

$$m_{SO} = m_{SO_0} - \sum_{i=1}^{n}\left(\frac{\Theta_{RBi}}{\Theta_{TRBi}} \times m_{RFi} \right) \tag{23}$$

where:

m_{SO_0} ≡ initial S/O mass, including rocket fuel

Θ_{TRBi} ≡ total rocket i burn time

m_{RFi} ≡ initial mass of rocket i fuel

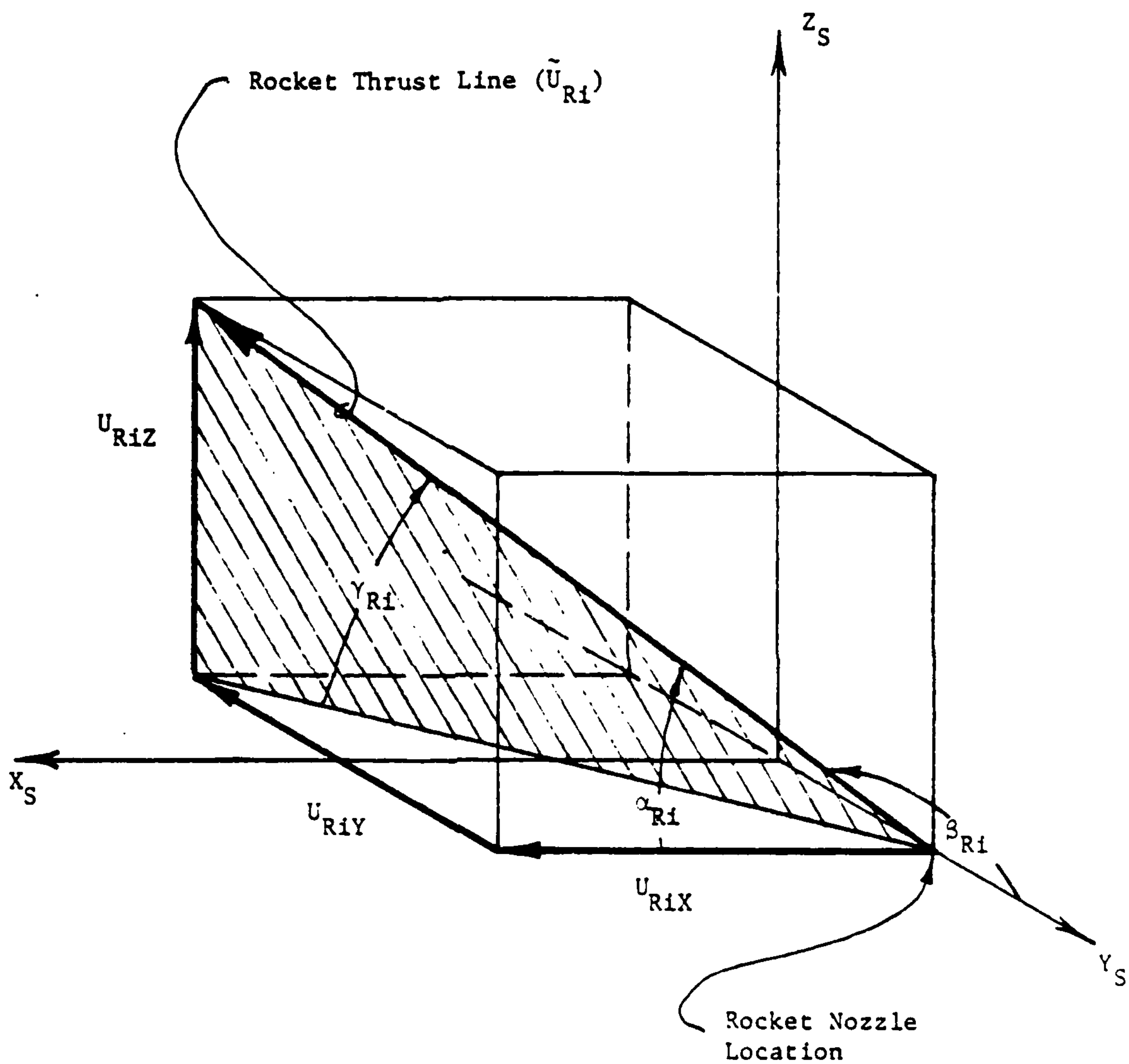


Figure 3-8. Rocket Thrust Line Unit Vectors and Direction Cosine Angles

3.4.4 Rail System. Several different rail system configurations are used for directing the seat/occupant out of the aircraft. The rail can be permanently mounted in the aircraft with either rollers or slider blocks (slippers) attached to the seat, or the rail may be mounted on the seat with slippers attached to the aircraft. There are also "rail-within-a-rail" systems in which both the seat and the aircraft are provided rails which contact each other. The GESS program allows the user to specify either type of system.

The program determines the displacement of each slipper from the rail, perpendicular to the RCS Z-axis, at each integration time step. For the rail-within-a-rail option, four slippers, each pair separated by the rail length, are assumed. Based on this displacement, a restoring force is computed, constraining the slider blocks to the rails.

Up to six slippers can be specified; they are numbered consecutively in the order in which their initial positions are entered in input. The deflection vector from the ith slipper to its respective rail, $\bar{r}_{SSBi}$, which is perpendicular to the RCS Z-axis, is denoted as:

$$\tilde{\delta}_{SSBi} = (\delta_{SSBix}, \delta_{SSBiy}, 0) = \tilde{r}_{SSBi} - \tilde{\delta}_{SSBiz} \tag{24.a}$$

and is illustrated in Figure 3-9. Solving for $\tilde{\delta}_{SSBi}$, we obtain, in the RCS:

$$\tilde{\delta}_{SSBi} = \begin{bmatrix} r_{Sx} \\ r_{Sy} \\ 0 \end{bmatrix} + D_{Sr} \begin{bmatrix} r_{SSBix} \\ r_{SSBiy} \\ 0 \end{bmatrix} - \begin{bmatrix} r_{SBiox} \\ r_{SBioy} \\ 0 \end{bmatrix} \tag{24.b}$$

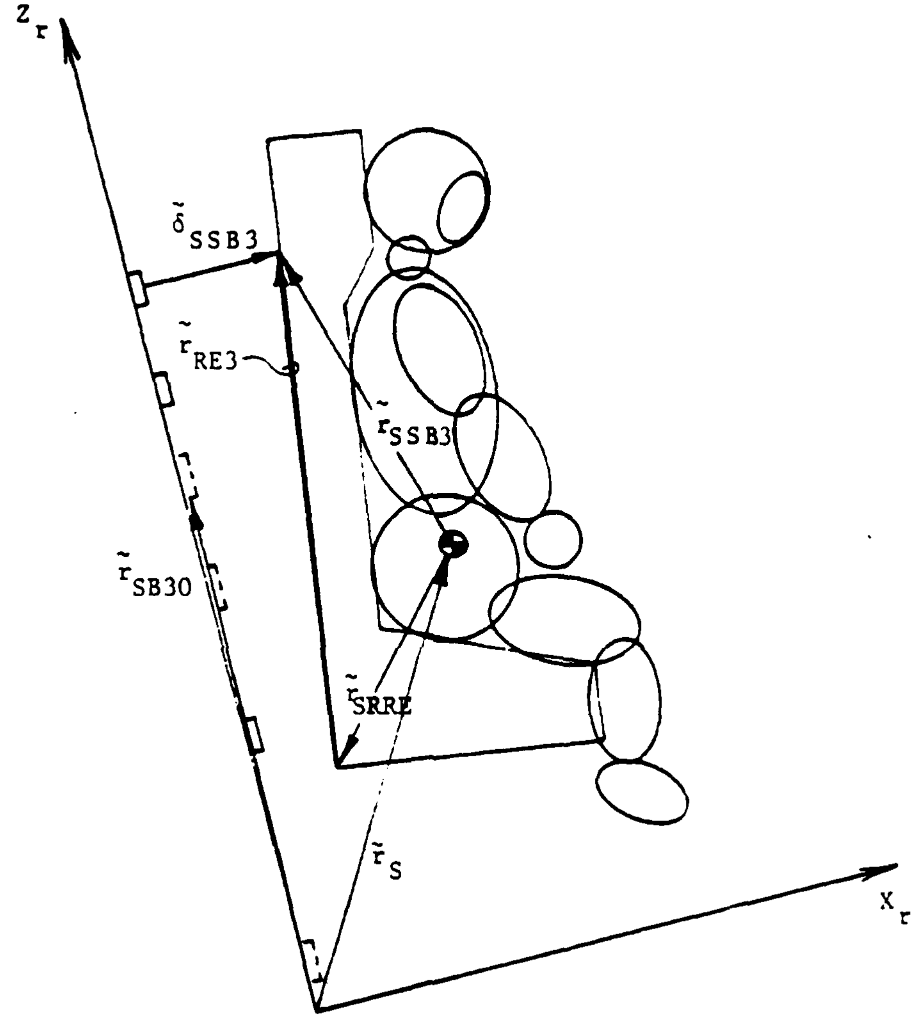


Figure 3-9. Rail to Slipper Deflection Vector

where:

$\tilde{r}_{Sj}$ ≡ vector components of S/O CG position in RCS

D_{Sr} ≡ SCS to RCS DCM

$\tilde{r}_{SSBij}$ ≡ components of vector from S/O CG to slipper i in SCS

$\tilde{r}_{SBioj}$ ≡ vector components of slipper i initial position in RCS

The reaction forces at slipper i are computed by:

$$F_{SBix} = -k_x \, \delta_{SSBix} \tag{25.a}$$

$$F_{SBiy} = -k_y \, \delta_{SSBiy} \tag{25.b}$$

where:

k_j ≡ slipper i spring constant in j direction

and, the frictional force at slipper i, F_{SBiz}, is computed by:

$$F_{SBiz} = -\mu_f (F_{SBix}^2 + F_{SBiy}^2)^{1/2} \tag{25.c}$$

where: μ_f ≡ linear coefficient of friction between rail and slipper.

The summation of the rail/slipper forces acting on the S/O in the SCS then becomes:

$$\tilde{F}_r = D_{Sr} \sum_{i=1}^{6} \tilde{F}_{SBi} \tag{26}$$

The vector from the S/O CG to the rail/slipper contact point i, $\tilde{r}_{SSBi}$, is found from: (refer to Figure 3-9 for vector definitions)

$$\tilde{r}_{SSBi} = D_{Sr}^T [\tilde{r}_{SRRE} + \tilde{r}_{REi}] \tag{27}$$

The vector slipper moment about the S/O CG, $\tilde{M}_{SBi}$, is then given by:

$$\tilde{M}_{SBi} = \tilde{r}_{SSBi} \times \tilde{F}_r \tag{28}$$

An additional pitching moment, M_τ, caused by the torsional bending of the rail as the S/O angular position varies relative to the RCS, is given by:

$$M_\tau = -K_\tau(\theta_{Sr} - \theta_{Sr0}) \tag{29}$$

where:

K_τ ≡ torsional bending constant

θ_{Sr} ≡ pitch angle of seat to rail

θ_{Sr0} ≡ initial pitch angle of seat to rail

Therefore, the rail/slipper moment vector acting on the S/O in the SCS, is:

$$\tilde{M}_r = D_{Sr} \sum_{i=1}^{6} \tilde{M}_{SBi} + \tilde{M}_\tau \tag{30}$$

3.4.5 <u>Aerodynamic Drag</u>. The forces acting on the seat/occupant and seat alone due to aerodynamic drag are based upon tabular data similar to that found in Reference 6. These data, in the form of drag coefficients, are functions of the angles of attack and sideslip and of Mach number. The coefficients are modified, when appropriate, to compensate for the partial wind exposure encountered as the S/O begins to emerge from the aircraft.

First, the velocity of the S/O or S/A with respect to the air, $\tilde{U}_{SA}$, found from:

$$\tilde{U}_{SA} = \tilde{U}_S - D_{SE}\tilde{W}_E \tag{31}$$

and its scalar magnitude, V_{SA}, is:

$$V_{SA} = (u_{SA}^2 + v_{SA}^2 + w_{SA}^2)^{1/2} \tag{32}$$

where:

$\tilde{U}_S \equiv$ S/O or S/A velocity vector wrt EFCS

$D_{SE} \equiv$ SCS to EFCS DCM

$\tilde{W}_E \equiv$ wind velocity vector

$u_{SA}, v_{SA}, w_{SA} \equiv$ vector components of $\tilde{U}_{SA}$

The angles of attack, α_s, and sideslip, β_s, as shown in Figure 3-10, are determined by:

$$\alpha_s = -\tan^{-1}(w_{SA}/u_{SA}) \tag{33}$$

$$\beta_s = \sin^{-1}(v_{SA}/V_{SA}) \tag{34}$$

The Mach number is found from:

$$N_M = \frac{V_{SA}}{V_x} \tag{35}$$

where:

$$V_x = 49.0212 \times T_{amb}^{1/2} \tag{36}$$

$T_{amb} \equiv$ ambient air temperature

The aerodynamic force vector, $\tilde{F}_A$ is then given by:

$$\tilde{F}_A = \rho_{amb} V_S^2 A_S f_x \tilde{C}_{FS}/2 \tag{37}$$

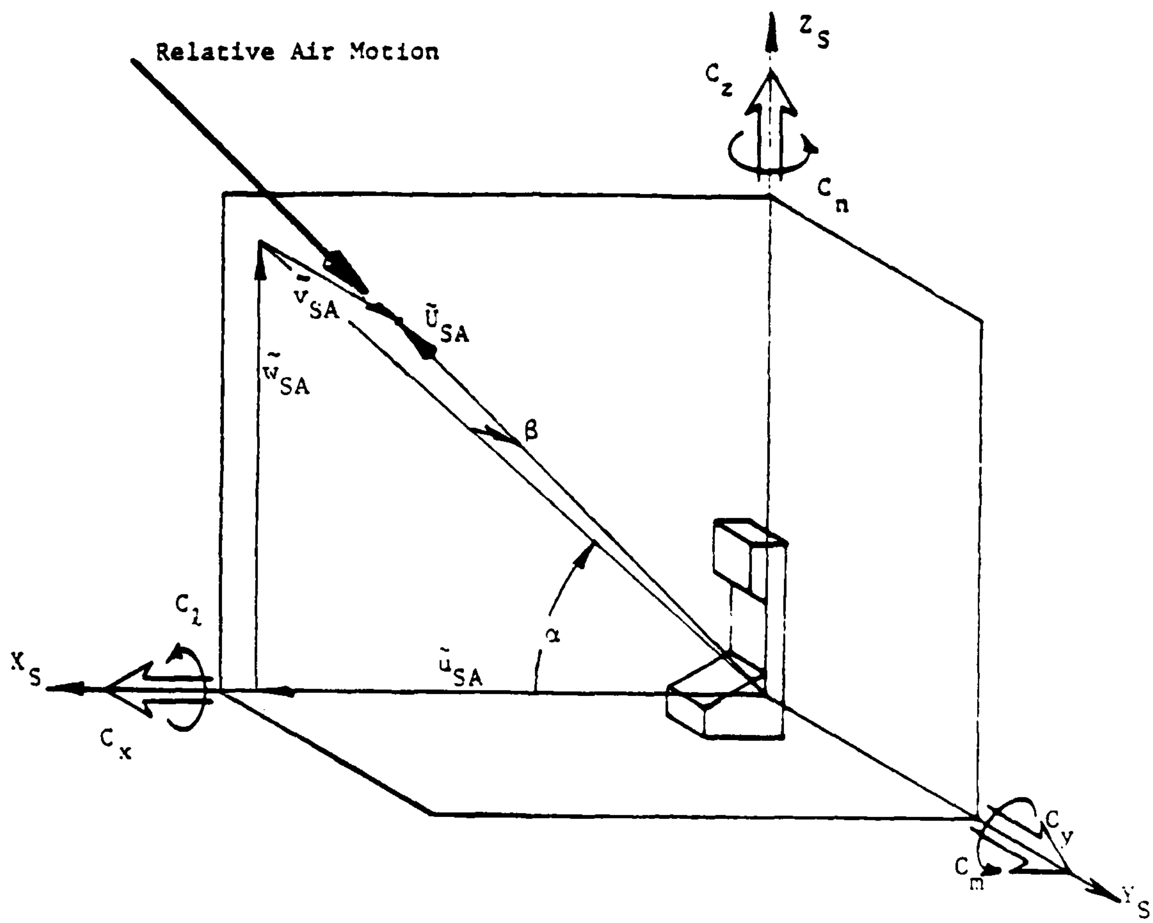


Figure 3-10. Seat/Occupant Aerodynamic Force and Moment Angles and Coefficients

where:

ρ_{amb} ≡ ambient air density

f_x ≡ fraction of S/O exposed to the air stream

A_S ≡ aerodynamic reference area of S/O or S/A

$\tilde{C}_{FS}$ ≡ vector of S/O or S/A aerodynamic force coefficients, functions of α_s, β_s, and M_u

The aerodynamic moment vector, $\tilde{M}_A$, is given by:

$$\tilde{M}_A = (\rho_{amb} V_{SA}^2 \tilde{r}_{SSCG} \times \tilde{C}_{FS} + L_{RS} \tilde{C}_{MS})/2 \quad (38)$$

where:

$\tilde{r}_{SSCG}$ ≡ vector location of the seat center of gravity in SCS

$\tilde{C}_{MS}$ ≡ vector of S/O or S/A aerodynamic moment coefficients, functions of α_s, β_s, and N_M

L_{RS} ≡ aerodynamic reference length of S/O or S/A

As the S/O moves from the cockpit into the airstream, the reference area, reference length, and center of aerodynamic forces are modified to account for the partial wind exposure. Hence, if we define ψ as the fraction of the S/O exposed:

$$\psi = \frac{|Z_{RSB}| + Z_{SA} - Z_{CPH}}{Z_{SA}}$$

then:

$$A_S = \begin{cases} \psi A_{SF}, & (|Z_{RSB}| + Z_{SA}) < Z_{CP} \quad (39.a) \\ A_{SF}, & (|Z_{RSB}| + Z_{SA}) > Z_{CP} \quad (39.b) \end{cases}$$

Similarly:

$$L_{RS} = \begin{cases} \psi L_{RSF}, & (|Z_{RSB}|+Z_S) < Z_{CP} \quad (40.a) \\ L_{RSF}, & (|Z_{RSB}|+Z_S) > Z_{CP} \quad (40.b) \end{cases}$$

where:

A_{SF} ≡ aerodynamic reference area of S/O fully out of aircraft

L_{RSF} ≡ aerodynamic reference length of S/O fully out of aircraft

Z_{RSB} ≡ travel of RCS Z-position of seat bottom

Z_{SA} ≡ S/A height in RCS

Z_{CPH} ≡ cockpit height in RCS

The partially exposed aerodynamic reference point (center of aerodynamic forces), Z_{SRP}, is found from:

$$Z_{SRP} = Z_{SSRP} + (Z_{SBOT} - Z_{SSRP} + Z_{SA})\ (1 - \psi) \qquad (41)$$

where:

Z_{SSRP} ≡ fully exposed aerodynamic reference point

Z_{SBOT} ≡ SCS Z-position of seat bottom

As the fully-exposed S/O or S/A rotates, a retarding moment tends to oppose this rotation due to aerodynamic damping. GESS has incorporated this moment in the form of a damping factor, f_D, such that:

$$\tilde{\omega}_{Sd} = \tilde{\omega}_S\ f_D \qquad (42)$$

where:

$$f_D = \exp\ (-10\ C_D \Delta t_i) \qquad (43)$$

and

$\tilde{\omega}_{Sd}$ ≡ dampened rotational velocity of S/O or S/A

$\tilde{\omega}_{S}$ ≡ calculated rotational velocity of S/O or S/A

C_D ≡ input damping coefficient $(0<C_D\leq 1)$

Δt_i ≡ integration time step for simulation phase i

In the OACS, the aerodynamic forces are computed based upon a fixed, multidimensional, aerodynamic reference area where no rotational effects are assumed. First, the O/A velocity with respect to the air, U_{OA}, is found from:

$$\tilde{U}_{OA} = \tilde{U}_O - \tilde{W}_E \tag{44}$$

and its scalar magnitude, V_{OA}, is:

$$V_{OA} = (u_{OA}^2 + v_{OA}^2 + w_{OA}^2)^{1/2} \tag{45}$$

where:

$\tilde{U}_O$ ≡ O/A velocity vector wrt EFCS

u_{OA}, v_{OA}, w_{OA} ≡ vector components of $\tilde{U}_{OA}$

The O/A angles of attack, α_{OA}, and sideslip, β_{OA}, are found from:

$$\alpha_{OA} = \sin^{-1}(w_{OA}/V_{OA}) \tag{46}$$

$$\beta_{OA} = \tan^{-1}(v_{OA}/u_{OA}) \tag{47}$$

The vector components of the aerodynamic force coefficient, C_F, are determined from:

$$C_{FX} = -\mathrm{SIGN}[(\cos\alpha_{OA}\cos\beta_{OA}),\ u_{OA}] \tag{48.a}$$

$$C_{FY} = -\mathrm{SIGN}[(\cos\alpha_{OA}\sin\beta_{OA}),\ v_{OA}] \tag{48.b}$$

$$C_{FZ} = -\mathrm{SIGN}[(\sin\alpha_{OA}),\ w_{OA}] \tag{48.c}$$

where the SIGN function assigns the first argument the sign of the second. Therefore, the total vector OA aerodynamic force, F_{AO}, is

$$\tilde{F}_{AO} = \rho_{amb} V_{OA}^2 A_{OA} \tilde{C}_F / 2 \tag{49}$$

3.4.6 Stabilization. Various mechanisms are used to stabilize the S/O during sustainer rocket burn. The GESS program includes provisions for simulating a Directional Automatic Realignment of Trajectory (DART) system. As the seat moves away from the aircraft, the DART lines play out through a brake mechanism in the DART frame. The brake force is assumed to act along each DART line from the time that the DART line first becomes stretched to the time that the lines separate from the seat (see Figure 3-11).

The vector DART force, F_{Di}, for a given DART line i, presented in the SCS, is given by:

$$\tilde{F}_{Di} = \frac{1}{2} \frac{K_{DF}}{L_{DL_i}} \tilde{r}_{DCAP_i} \tag{50}$$

where

K_{DF} ≡ DART force constant

L_{DL_i} ≡ length of dart line i from confluence to attachment points

$\tilde{r}_{DCAP_i}$ ≡ vector from confluence to attachment points of dart line i.

The total DART force, $\tilde{F}_D$, then becomes:

$$\tilde{F}_D = \sum_{i=1}^{2} \tilde{F}_{Di} \tag{51}$$

The vector DART moment, M_{Di}, for a given DART line i, in the SCS, is given by:

$$\tilde{M}_{Di} = \tilde{r}_{SCP_i} \times \tilde{F}_{Di} \tag{52}$$

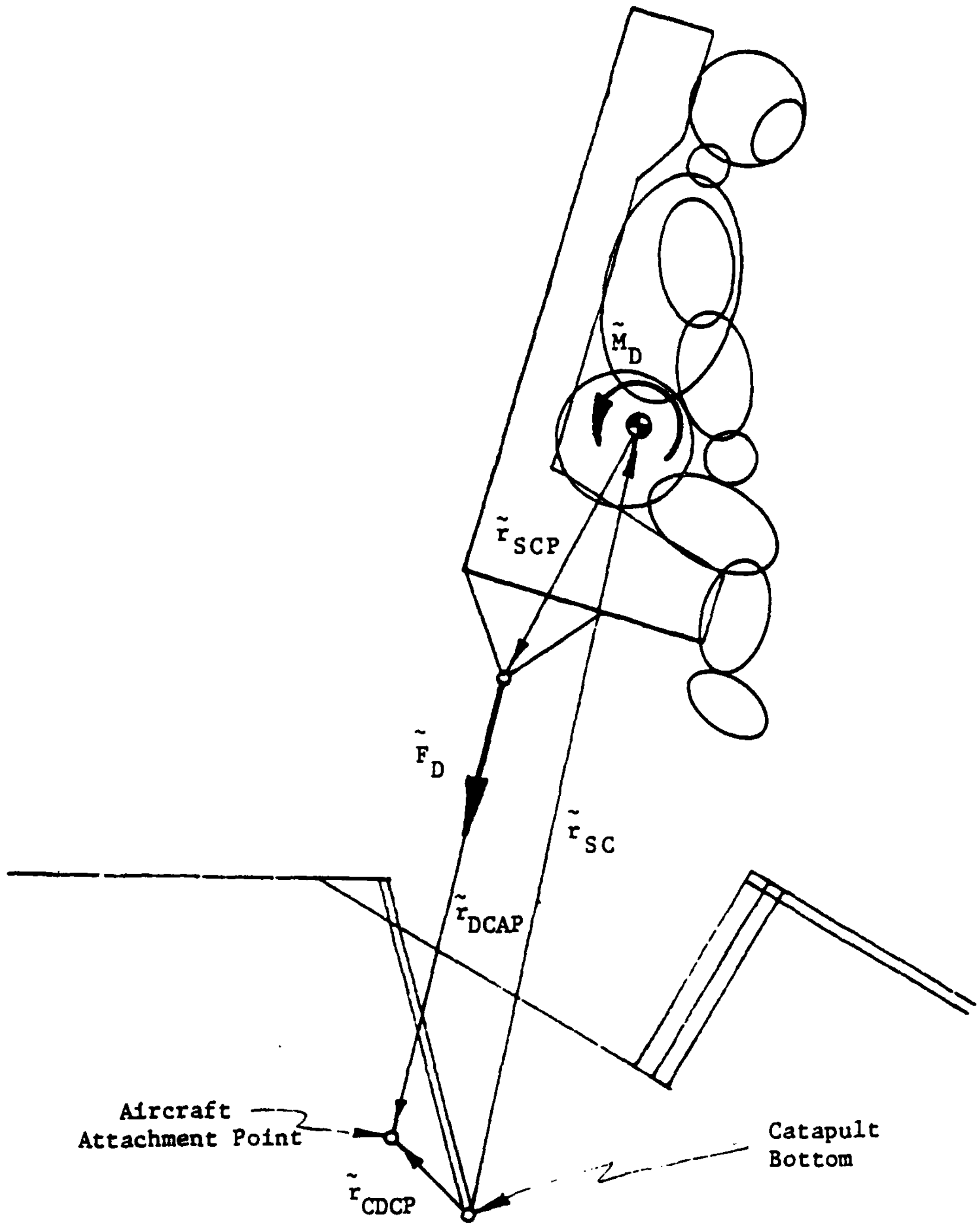


Figure 3-11. DART Forces and Moments

where:

$\tilde{r}_{SCP_i}$ ≡ vector from the seat center of gravity to the aircraft confluence point for DART line i

The total DART moment, $\tilde{M}_D$, then becomes:

$$\tilde{M}_D = \sum_{i=1}^{2} \tilde{M}_{Di} \tag{53}$$

3.4.7 Drogue Slug/Container. The aerodynamic drag force applied to the drogue slug/container, F_{DSC}, after its deployment is used to determine the drogue parachute acceleration. This force magnitude is determined by:

$$F_{DSC} = \rho_{amb} C_{DSC} A_{DSC} V_{DA}^2 / 2 \tag{54}$$

where:

C_{DSC} ≡ drogue slug/container drag coefficient

A_{DSC} ≡ drogue slug/container effective drag area

V_{DA} ≡ velocity magnitude of the drogue parachute being deployed by the slug/container relative to the air

$= (u_{DA}^2 + v_{DA}^2 + w_{DA}^2)^{1/2}$

u_{DA}, v_{DA}, w_{DA} ≡ components of vector $\tilde{U}_{DA}$

$\tilde{U}_{DA}$ ≡ $D_{SE}\tilde{U}_D - \tilde{W}$

D_{SE} ≡ SCS to EFCS DCM

$\tilde{U}_D$ ≡ drogue parachute velocity vector in EFCS

$\tilde{W}$ ≡ wind vector in EFCS

The axial components of $\tilde{F}_{DSC}$ are found from:

$$\tilde{F}_{DSC} = \frac{F_{DSC}}{V_{DA}} \tilde{U}_{DA} \tag{55.a}$$

and the initial slug/container acceleration, $\tilde{a}_{DSC_o}$, becomes:

$$\tilde{a}_{DSC_o} = \frac{1}{m_{DSC}} \tilde{F}_{DSC} \tag{55.b}$$

where:

m_{DSC} ≡ mass of the drogue slug/container

3.4.8 Parachutes. Both drogue and recovery parachute forces and moments are calculated similarly. Parachute release or deployment occurs at the time the parachute begins to leave the seat. After deployment, the parachute begins to develop or play out, but will not exert any force until the suspension line is fully extended (line stretch). Upon achieving line stretch, the parachute begins to fill and exert force. The total time required to completely fill the parachute is nearly always a function of the velocity of the S/O, and is determined by linear extrapolation from a user provided data table. The partially inflated diameter of the parachute, d_η, as a function of time, t, is calculated as:

$$d_\eta = d_{full} \frac{t-t_{ls}}{\Delta t_{ft}}, \quad (t_{ls} < t < t_{ls} + \Delta t_{ft}) \tag{56}$$

where:

d_{full} ≡ fully inflated parachute projected diameter

t_{ls} ≡ time at which parachute line stretch is achieved

Δt_{ft} ≡ total time required for parachute fill

The total force magnitude exerted by the parachute on the S/O or O/A is found from:

$$F_P = \rho_{amp} V_{SA}^2 C_{DP} d_\eta^2 / 8 \tag{57}$$

where

V_{SA} $\equiv$ total resultant velocity of S/O wrt air

$= (u_{SA}^2 + v_{SA}^2 + w_{SA}^2)^{1/2}$

C_{DP} $\equiv$ parachute drag coefficient

The parachute force vector, $\tilde{F}_P$, is componentized as:

$$F_{Px} = F_P \cos\alpha_p \cos\beta_p \tag{58.a}$$

$$F_{Py} = F_P \cos\alpha_p \sin\beta_p \tag{58.b}$$

$$F_{Pz} = F_P \sin\alpha_p \tag{58.c}$$

where:

α_p $\equiv$ parachute angle of attack wrt air

$= \sin^{-1} (w_{SA}/V_{SA})$

β_p $\equiv$ parachute angle of sideslip wrt air

$= \tan^{-1} (v_{SA}/u_{SA})$

The moment, $\tilde{M}_P$, exerted on the S/O by the parachute is found from:

$$\tilde{M}_P = \tilde{r}_{SP} \times \tilde{F}_P \tag{59}$$

where

$\tilde{r}_{SP}$ $\equiv$ position vector from S/O center of gravity to parachute confluence point

3.4.8.1. The drogue parachute (drogue) is deployed from the seat by the drogue slug/container until the drogue suspension line is completely extended (line stretch). The total time required to achieve line stretch may be specified on input as either extrapolation table values based on S/O linear velocity, or it may be calculated based upon the acceleration provided by the slug/container. At this time the drogue begins to fill. The total time required to completely fill the drogue is also determined by linearly extrapolating input table values based on S/O velocity.

An option is provided to allow the simulation of a duplex VELCON drogue system. The VELCON drogue consists of two tandem drogues, a relatively small one preceded by a larger one. The two drogues are connected by a velocity-calibrated breakaway bridle. At high speeds, the force generated by the large drogue causes the bridle to fail, separating it from the system and limiting the force imposed on the S/O. At low speeds, the forces of the two drogues are additive. The speed at which the large drogue separates is part of the program input, along with the descriptions of the two drogues.

3.4.8.2. The recovery parachute (chute) is deployed from the seat by various mechanisms, depending upon such variables as the ejection altitude, velocity, drogue force, and others. The GESS program allows the user to specify either a fixed time of deployment or to use an extrapolated time of deployment based on table values that are functions of the S/O velocity. The user can also specify the altitude above which the chute will not deploy (CHALT2), and the altitude below which the parachute will deploy at the specified deployment time (CHALT1). Between these two altitudes the user can specifiy an additional fixed time delay, or a variable delay based upon the seat vertical deceleration. The latter option determines a time of deployment, t_{deploy}, based on:

$$t_{deploy} = t_{delay} + i\Delta t \tag{60}$$

where:

t_{delay} ≡ fixed deployment time delay

i ≡ number of time steps during which the vertical acceleration exceeds a specified acceleration limit

Δt ≡ integration step time increment

The total time required to achieve line stretch is specified in input as linear extrapolation table values, based upon S/O linear velocity. The user has the option of determining parachute fill time by extrapolation tables based on S/O velocity or by calculations based on theory. The latter approach calculates the area under the curve representing current parachute volume, and then compares this volume to the actual parachute volume at full inflation. If the two volumes vary by more than a given tolerance limit, a new value for parachute filling time is assumed, and the area under the new volume curve is calculated. The proper value for parachute filling time is determined when the two volumes are within the tolerance limit. A more detailed discussion can be found in Reference 7.

The maximum parachute volume, V_{max}, is found from:

$$V_{max} = \frac{\pi}{12} D_P^3 \tag{61}$$

where:

D_P ≡ projected parachute diameter

The projected parachute area, A_P, is found from:

$$A_P = \sum_{i=1}^{10} A_{Pi} \tag{62}$$

where:

$$A_{Pi} = \frac{Z_i R_{1i}}{3(P_2 R_{2i} + P_{3i}/A)} \tag{63.a}$$

$$Z_i = \begin{cases} .1, & T_{Di} = 1. \\ .4, & T_{Di} = .1,\ .3,\ .5,\ .7,\ .9 \\ .2, & T_{Di} = .2,\ .4,\ .6,\ .8 \end{cases} \tag{63.b}$$

$$R_{1i} = T_{Di}(P_{1i} T_{Di}^{1/3} - 2.2p) \tag{63.c}$$

$$R_{2i} = P_{3i} \log_e (P_{3i}/A) - 11.25\ T_{Di} \tag{63.d}$$

$$P_{1i} = 1 + T_{Di}(2.2p - 1) \tag{63.e}$$

$$P_{2i} = BV_O/253.125 \tag{63.f}$$

$$P_{3i} = 11.25\ T_{Di} + A \tag{63.g}$$

T_{Di} = fraction of total chute filling time

= 0. to 1.0

$$A = \frac{5000\ W_{OA}}{g(\rho/\rho_o) D_{ODC}^2} \tag{63.h}$$

$$B = \frac{120 T_{FP} C_D S_P}{D_{ODC}^3} \tag{63.i}$$

W_{OA} ≡ weight of the occupant alone after seat separation

g ≡ gravitational acceleration constant

ρ ≡ localized air density

ρ_o ≡ air density at sea level

D_{ODC} ≡ parachute flattened diamter = π/D_P

D_P ≡ parachute projected diameter

T_{FP} ≡ estimated parachute filling times, initially = 1.0 sec

C_D ≡ parachute drag coefficient

S_P ≡ parachute projected area = $\pi D_P^2/4$

p ≡ parachute porosity

V_o ≡ free stream air velocity

The calculated parachute volume becomes:

$$Vol = \frac{T_{FP} V_o^2 D_{ODC} A_C}{\pi} \tag{64}$$

This volume is then compared with the actual volume:

$$\frac{\left|V_{max} - V_O\right|}{V_{max}} < 0.01 \tag{65}$$

If the tolerance condition is not met, then T_{Fp} is incremented or decremented by half of the difference between the curren value and either its closest previously tried value or zero.

3.5 Special Features

3.5.1 Dynamic Response Index. The user is offered the option of having the program determine the maximum value of the Dynamic Response Index (DRI) during the time period of seat motion prior to rail separation. The DRI is a standard measure of the acceleration stress applied to the seat occupant during ejection.

The DRI is determined at every integration time step during in aircraft acceleration by first numerically integrating the following second order equation given in Section 6.5.1 of MIL-S-9479B(USAF):

$$dS_Z = V_Z \tag{66.a}$$

$$dV_Z = A_Z - 23.7\ V_Z - 2798.41 S_Z \tag{66.b}$$

$$A_Z = \ddot{Z}_s - (\ddot{Z}_s - \ddot{Z}_{s-1})[(t - t_{-1})/\Delta t] \tag{66.c}$$

where:

A_Z ≡ vertical acceleration in SCS during time step

$\ddot{Z}_s$ ≡ vertical acceleration in SCS at time t

$\ddot{Z}_{s-1}$ ≡ vertical acceleration in SCS at time t_{-1}

Δt ≡ length of integration time step

Hence, the time step value of DRI, I_{DR}, is taken from:

$$I_{DR} = C_{DRI} S_Z \tag{67.a}$$

where:

C_{DRI} ≡ dynamic response index constant

and

$$S_Z = \int dS_Z \tag{67.b}$$

$$= \iint dV_Z \tag{67.c}$$

When selected, the DRI option will save the maximum DRI value calculated over the pre-separation period and the time at which this value occurred.

3.5.2 Dynamic Center of Gravity. Previous ejection seat tests have demonstrated a considerable oscillatory motion between the occupant and the seat prior to seat/occupant separation. Since the relationship between the S/O center of mass and the rocket thrust line can be critical to the accurate determination of the S/O trajectory, a user-optional routine has been included in GESS to approximate the shifting of the S/O center of gravity (CG) location throughout this phase of the simulation. The development, methodology, and evaluation of this dynamic CG mathematical model used for this routine is described in Reference 8.

The dynamic CG model is represented by an orthogonal three degrees of freedom spring and damper system. A two-dimensional representation of this system is shown in Figure 3-12. The general equation of motion for such a system is given by:

$$\ddot{\tilde{\delta}} + 2c\omega_o\dot{\tilde{\delta}} + \omega_0^2\tilde{\delta} = A(t) \tag{68}$$

where

$\tilde{\delta}$ ≡ deflection vector of occupant relative to seat

$\dot{\tilde{\delta}}, \ddot{\tilde{\delta}}$ ≡ first and second time derivatives of deflection vector

$c = \dfrac{b}{2mW_o}$

b ≡ damping constant

m ≡ mass of occupant

$\omega_o = (K/m)^{1/2}$

K ≡ spring constant

$A(t)$ ≡ time dependent external acceleration

A major feature of the dynamic CG model is its use of non-linear spring constants. The spring constants of all three axes incorporate different values

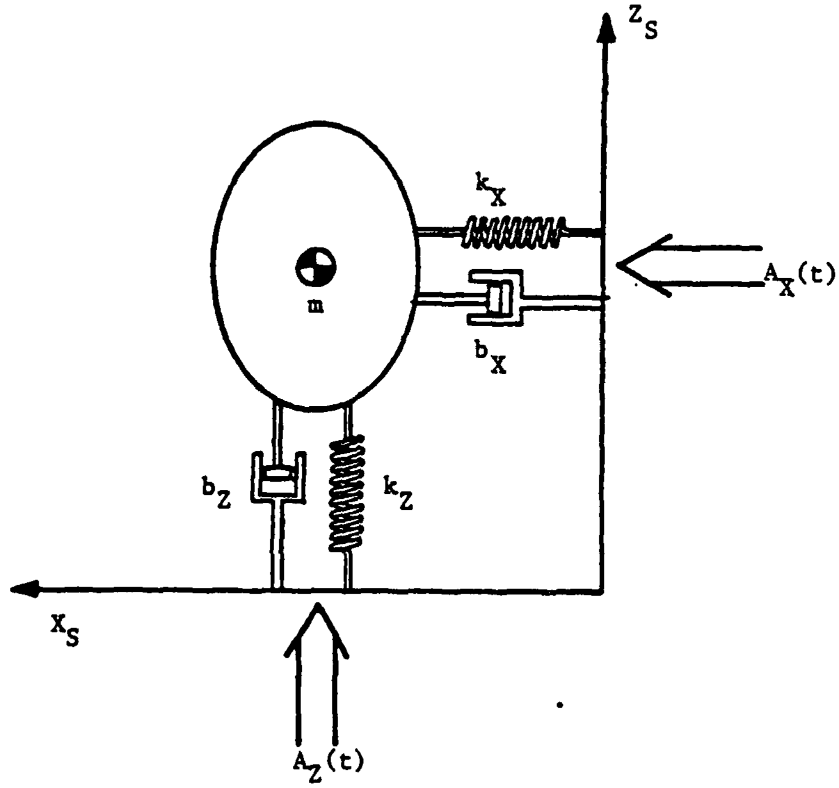


Figure 3-12. Dynamic CG Model

between the positive and negative displacement directions. Both the SCS X and Z axes incorporate a positive "slack" displacement zone in which there is no spring force exerted on the occupant. Further, the Z-axis incorporates two separate spring constant values in the negative direction; this simulates the effects of the initial compression of the seat cushion before reaching the "bottoming" displacement corresponding to the cushion thickness. Hence, the vertical (Z-axis) spring constant can be represented as:

$$K_Z = 0, \quad Z = 0 \text{ to } Z_{slack}$$

$$K_Z = K_p, \quad Z = Z_{slack} \text{ to } +\infty$$

$$K_Z = K_{n1}, \quad Z = 0 \text{ to } Z_{bottom}$$

$$K_Z = K_{n2}, \quad Z = Z_{bottom} \text{ to } -\infty$$

Typical dynamic CG spring constant curves are presented in Figures 4-16, 4-17, and 4-18 on pages 4-35 to 4-37.

The displacement of the occupant CG relative to the seat is determined by numerically integrating Equation 68 at each time step until seat/occupant separation. This displacement is then used to update the S/O CG location in the SCS, upon which the remaining position vectors are similarly updated.

3.5.3 Thrust Vector Control. The user-optional Thrust Vector Control (TVC) feature simulates the vertical-seeking maneuver incorporated into the developmental Maximum Performance Ejection Seat (MPES). In this manuever, a single seat booster rocket (SBR), located on the seat bottom, can be gimballed to control the roll and pitch movement of the S/O in a manner which attempts to bring the S/O to an upright orientation. An on-board microprocessor updates the direction cosine matrix (DCM) from sensor data identifying the current seat orientation at fixed time intervals from catapult ignition to rocket burnout. A series of TVC thrust signal transfer equations are numerically integrated to produce the orientation instruction given to the rocket nozzle rotation actuators. The development of the vertical-seeking maneuver algorithm upon which the TVC routine is based was conducted at the Naval Weapons Center, China Lake, CA. The brief formulation that follows has been included for completeness only. A more detailed analysis than that which follows can be found in Reference 9.

The equations governing the TVC pitch rate compensation are as follows:

$$\dot{X}_3 = 500(\dot{\theta}_{ST}-X_3) \tag{69}$$

$$\dot{X}_4 = X_5 \tag{70}$$

$$\dot{X}_5 = 250000(X_3-X_4)-500X_5 \tag{71}$$

$$\dot{X}_6 = C_{29}\xi_2 - C_{30}\ X_4 - 100X_6 \tag{72}$$

$$\theta_T = 5(\dot{X}_6 + 20\ X_6),\ |\theta_T|<\theta limit \tag{73}$$

where:

X_i ≡ signal transfer variables

$\dot{X}_i$ ≡ time derivative of X_i

$\dot{\theta}_{ST}$ ≡ pitch rate of the TVC coordinate system (TVCCS) wrt the SCS

ξ_i ≡ rocket command angles

C_i ≡ fixed constants

θ_T ≡ intermediate value of rocket pitch wrt TVCCS

θ_{limit} ≡ rocket pitch angle limit

The corresponding TVC roll compensation equations are:

$$\dot{X}_7 = 500(\dot{\Phi}_{ST}-X_7) \quad (74)$$

$$\dot{X}_8 = X_9 \quad (75)$$

$$\dot{X}_9 = 250000(X_7-X_8)-500X_9 \quad (76)$$

$$\dot{X}_{10} = C_{31}\xi_1-C_{32}X_8-100X_{10} \quad (77)$$

$$\Phi_T = 5(\dot{X}_{10}+20X_{10}),\ |\Phi_T|<\Phi_{limit} \quad (78)$$

where

$\dot{\Phi}_{ST}$ ≡ roll rate of the TVCCS wrt the SCS

Φ_T ≡ intermediate value of rocket roll wrt TVCCS

Φ_{limit} ≡ rocket roll angle limit

The equations governing control of the rocket pitch angle are then:

$$\dot{X}_{11} = 2861000\ \Theta_T-31.45X_{11} \quad (79)$$

$$\dot{X}_1 = \begin{cases} 0.0, & X_1 < (\Theta_{limit} + 0.25) \\ X_{12}, & (\Theta_{limit} + 0.25) < X_1 \end{cases} \quad (80)$$

$$\dot{X}_{12} = X_{11} - 48.26X_{12} - 90992X_1 \quad (81)$$

$$\Omega_1 = X_1 + \Theta_{RT} \quad (82)$$

and the corresponding rocket roll angle control equations are:

$$\dot{X}_{13} = 2861000\Phi_T-31.45X_{13} \quad (83)$$

$$\dot{X}_2 = \begin{cases} 0.0, & X_2 < (\Phi_{limit} + 0.25) \\ X_{14}, & (\Phi_{limit} + 0.25) < X_2 \end{cases} \quad (84)$$

$$\dot{X}_{14} = X_{13}-48.26X_{14}-90992X_2 \quad (85)$$

$$\Omega_2 = X_2 \quad (86)$$

where:

Ω_i ≡ rocket thrust line angles, generated by the signal transfer equations, wrt TVCCS

Θ_{RT} ≡ initial angle of rocket wrt TVCCS

We now find the TVC Euler angles to be:

$$\alpha_{TVC} = \sin \Omega_1 \cos \Omega_2 \tag{87.a}$$

$$\beta_{TVC} = \sin \Omega_2 \tag{87.b}$$

$$\gamma_{TVC} = \cos \Omega_1 \cos \Omega_2 \tag{87.c}$$

Next, the TVC microprocessor code is simulated by integrating the angular rate data as follows:

$$d_{i,j} = \dot{\lambda}_i \delta_{tj} \ (i=1,2,3;\ j=1,2) \tag{88}$$

$$T_{di} = \sum_{j=1}^{2} d_{i,j} \tag{89}$$

$$\Delta\zeta = \zeta_s \delta_t \tag{90}$$

If $|T_{di}| > \Delta\zeta$, then $d_{i,2} = .007812 T_{di}/|T_{di}|$ (91.a)

and $d_{i,1} = T_{di} - .0078125 T_{di}/|T_{di}|$ (91.b)

If $|T_{di}| < \Delta\zeta$, then $d_{i,2} = T_{di}$ (92.a)

and $d_{i,1} = 0$ (92.b)

where:

$d_{i,j}$ ≡ angular displacement matrix

$\dot{\lambda}_i$ ≡ vector time derivative of TVC angular velocity wrt SCS

δ_{tj} ≡ integration time step length for increment j

T_{di} ≡ as defined

$\Delta\zeta$ ≡ as defined

ζ_s ≡ TVC processor sampling rate

Using the Crowder-Hession algorithm, the direction cosine matrices are updated as follows:

$$d_2' = d_2 - d_{3,2}\, d_1 \tag{93.a}$$

$$d_3' = d_3 + d_{2,2}\, d_1 \tag{93.b}$$

$$d_1' = d_1 + d_{3,2}\, d_2' \tag{93.c}$$

$$d_3 = d_3' - d_{1,2}\, d_2' \tag{93.d}$$

$$d_1 = d_1' - d_{2,2}\, d_3 \tag{93.e}$$

$$d_2 = d_2' + d_{1,2}\, d_3 \tag{93.f}$$

Finally, the rocket commands are updated, depending upon the DCM values, as follows:

If $d_3 > 0$:

$$\xi_1 = -d_2 \tag{94.a}$$

$$\xi_2 = d_1 \tag{94.b}$$

If $d_3 < 0$, $d_1 = d_2 = 0$, and $\dot{\theta}_{ST} = 0$:

$$\xi_1 = 2 \tag{95.a}$$

$$\xi_2 = 0 \tag{95.b}$$

If $d_3 < 0$, $d_1 = d_2 = 0$, and $\dot{\theta}_{ST} \neq 0$:

$$\xi_1 = 2\, \dot{\theta}_{ST} / |\dot{\theta}_{ST}| \tag{96.a}$$

$$\xi_2 = 0 \tag{96.b}$$

If $d_3 < 0$, and $|d_1| < |d_2|$:

$$\xi_1 = (|d_2| - 2) d_2 / |d_2| \tag{97.a}$$

$$\xi_2 = d_1 \tag{97.b}$$

If $d_3<0$, and $|d_1|>|d_2|$:

$$\xi_1 = -d_2 \tag{98.a}$$

$$\xi_2 = (2-|d_1|)\, d_1/|d_1| \tag{98.b}$$

3.6 Numerical Integration

Solution of the various differential equations found in all sections of the GESS program requires numerical integration techniques. Two different types of integration methods are used: the Runge-Kutta method, and the predictor-corrector method. The Runge-Kutta method is well known for its accuracy, but is not computationally efficient for programs with numerous time steps and large arrays. The predictor-corrector method yields reasonable accuracy with excellent computational efficiency.

3.6.1 Runge-Kutta.

Runge-Kutta formulas involve the computation of the value of a multivariate function at specified points without the prior calculation of the higher derivatives of the function. If we assume such functions as:

$$\frac{dx}{dt} = f(t,x,y) \tag{99.a}$$

and

$$\frac{dy}{dt} = g(t,x,y) \tag{99.b}$$

we will seek solutions:

$$x(t+h) = x(t) + \Delta x \tag{100.a}$$

and

$$y(t+h) = y(t) + \Delta y \tag{100.b}$$

where:

$$h \equiv \text{time step interval} = \Delta t$$

$$\Delta x = ak_1 + bk_2 + ck_3 + dk_4 \tag{101.a}$$

$$\Delta y = a\ell_1 + b\ell_2 + c\ell_3 + d\ell_4 \tag{101.b}$$

and the general form of the solution is found from:

$$k_1 = hf(t,x,y) \tag{102.a}$$

$$k_2 = hf(t + mh,\ x + mk_1,\ y + m\ell_1) \tag{102.b}$$

$$k_3 = hf[t + nh,\ x + nk_2 + (n - r)k_1,\ y + n\ell_2 + (n - r)\ell_1] \tag{102.c}$$

$$k_4 = hf[t + ph,\ x + sk_2 + tk_3 + (p-s-t)k_1,\ y + s\ell_2 + t\ell_3 + (p-s-t)\ell_1] \tag{102.d}$$

and similarly;

$$\ell_1 = hg(t,x,y) \tag{102.e}$$

$$\ell_2 = hg(t + mh,\ x + mk_1,\ y + m\ell_1) \tag{102.f}$$

$$\ell_3 = hg[t + nh,\ x + nk_2 + (n-r)k_1,\ y + n\ell_2 + (n-r)\ell_1] \tag{102.g}$$

$$\ell_4 = hg[t + ph,\ x + sk_2 + tk_3 + (p-s-t)k_1,\ y + s\ell_2 + t\ell_3 + (p-s-t)\ell_1] \tag{102.h}$$

The method may be extended for as many first-degree differential equations as are required. A more detailed discussion of Runge-Kutta methods can be found in any numerical methods textbook.

There are several variations of the Runge-Kutta method, each with its own advantages and disadvantages. In GESS, two variations are used. The first, the Kutta-Simpson one-third rule variation, is used for integrations involving relatively small arrays and short simulated time periods, such as in the calculations of the DRI (Section 3.5.1) and dynamic CG (Section 3.5.2). This method assumes constant values of:

$$m = n = r = 1/2 \tag{103.a}$$

$$p = t = 1 \tag{103.b}$$

$$s = 0 \tag{103.c}$$

$$a = d = 1/6 \tag{103.d}$$

$$b = c = 1/3 \tag{103.e}$$

GESS uses the Gill variation for integrating the very large trajectory arrays during the initial four time steps, since it minimizes the number of memory locations. This method assumes constant values of:

$$m = n = 1/2 \tag{104.a}$$

$$p = 1 \tag{104.b}$$

$$r = 1/\sqrt{2} \tag{104.c}$$

$$s = -1/\sqrt{2} \tag{104.d}$$

$$t = 1 + 1/\sqrt{2} \tag{104.e}$$

$$a = d = 1/6 \tag{104.f}$$

$$b = (1-1/\sqrt{2})/3 \tag{104.g}$$

$$c = (1+1/\sqrt{2})/3 \tag{104.h}$$

3.6.2 Predictor-Corrector. Predictor-Corrector forward integration methods involve the use of an initial prediction formula for the next time step value of a function, followed by the application of a more accurate corrector formula. By iterating these formulas until the solution converges, this procedure achieves successive improvements in both the function value and its subsequently calculated derivative. However, the Hamming variation of applying the predictor-correction method eliminates the need for iteration by further modifying each of the two equations based on a previously-derived error estimate[10]. Thus, the two-pass equations used in GESS based on previously-determined values of the function and derivative at equally spaced time intervals, become:

- Predictor: $$p_{+1} = y_{-3} + \frac{4}{3}h(2y'_0 - y'_{-1} + 2y'_{-2}) \qquad (105.a)$$
- Modifier: $$y_p = p_{+1} - \frac{112}{121}(p_0 - c_0) \qquad (105.b)$$
- Corrector: $$c_{+1} = \frac{1}{8}[9y_0 - y_{-2} + 3h(y'_{+1} + 2y'_0 - y'_{-1})] \qquad (105.c)$$
- Final Value: $$y_{+1} = c_{+1} + \frac{9}{121}(p_{+1} - c_{+1}) \qquad (105.d)$$

where:

y_k ≡ value of function at time step k

y'_k ≡ value of function derivative at time step k

p_k ≡ predicted value of function at time step k

c_k ≡ corrected value of function at time step k

h ≡ time step interval

3.6.3 Integration Arrays. The large number of equations and saved values associated with many of the trajectory integrations in GESS resulted in the development of a highly structured integration array logic. This logic maintains the current value of each integration equation, in addition to all intermediate or previous equation values for both the Runge-Kutta and predictor-corrector methods. Thus, the initial four time steps can be integrated by the Runge-Kutta routine, and subsequent integrations performed by the predictor-corrector routine.

The first value of each array indicates the number of equations involved in the integration. The remaining array values are then ordered, in accordance with the number of equations, as described in Table 3-1.

Table 3-1. Integration Array Values

Array Location	Description
1	number of equations (N)
2 — (1+N)	results of integrations - equation values
(2+N) — (1+2N)	equation derivatives
(2+2N) — (1+3N)	current Runge-Kutta K-values
(2+3N) — (1+4N)	intermediate Runge-Kutta K-value summations
(2+4N) — (1+5N)	intermediate equation values
(2+5N) — (1+6N)	equation values at (time-Δt)
(2+6N) — (1+7N)	equation values at (time-2Δt)
(2+7N) — (1+8N)	equation values at (time-3Δt)
(2+8N) — (1+9N)	equation values at (time-4Δt)
(2+9N) —(1+10N)	equation derivatives at (time-Δt)
(2+10N)—(1+11N)	equation derivatives at (time-2Δt)
(2+11N)—(1+12N)	equation derivatives at (time-3Δt)
(2+12N)—(1+13N)	predictor values at currect time
(2+13N)—(1+14N)	predictor values at (time+Δt)
(2+14N)—(1+15N)	corrector values at current time
(2+15N)—(1+16N)	corrector values at (time+Δt)

4.0 INPUT PREPARATION

4.1 General Procedures

The GESS program has been developed to use a series of specific steps or procedures for its proper execution. The program was developed using the Control Data Corporation computers located at the Naval Air Development Center with the KRONOS operating system, and was programmed using the ASCII FORTRAN IV language[11,12,13]. Slight modifications may be necessary if the program is to be used on other computer systems.

The first step in the execution of the program is to create a series of aerodynamic coefficient tables using a pre-processing program called ACT[14]. This routine analyzes a file of raw data from wind tunnel tests consisting of aerodynamic forces and moments acting on the seat/occupant, occupant alone, or seat alone. The program generates a random access file of numerically smoothed, tabular, aerodynamic coefficients which are used in subsequent runs of the GESS program. Once a table has been generated for a specific seat or occupant configuration, it may be reused for all subsequent GESS runs relevant to that configuration. The procedure for generating the ACT file is generally discussed in Section 4.2 and detailed in Appendix A. A description of the theoretical concepts involved can be found in Reference 14.

Next, the GESS input file is created. All program variables are listed in a specific format, which is detailed in Section 4.3. If a previous input file exists for the specific seat and occupant configuration, a relatively few variable changes can usually produce the new input file with minimum effort.

Finally, the simulation job stream file is created. This is the list of commands to the computer which will control the program execution and assemble the output report data. The job stream is detailed for the KRONOS operating system in Section 4.4.

After the submission of the job stream and subsequent program execution, a series of simulation reports, detailed in Section 5.1, are available from the output file. These reports may be reviewed and analyzed according to the user's specific needs. Also, two plotting files may be created at the user's option for further analysis using post-processing routines, such as the DRAS utility program. This program, discussed in Section 5.2, and detailed in Reference 15, performs various data manipulation and graphic function routines using the data from the program plotting files. The CALCOMP-type plots generated can greatly enhance the interpretation of program output.

4.2 Aerodynamic Coefficient Tables

During the execution of the GESS program, equally spaced aerodynamic coefficients are required for computing the aerodynamic forces acting upon the seat/occupant system. These coefficients are usually derived through wind tunnel experiments using the subject ejection seat(6). The forces and moments data produced by these tests are used as input for the Aerodynamic Coefficient Table (ACT) program(14), which creates the necessary coefficient tables as functions of the seat orientation and velocity. The ACT program provides an efficient method for creating, modifying, and storing these aerodynamic coefficient tables on random access files for retrieval by GESS during simulation execution. The ACT program was closely modeled after the RFWTHR program (4).

Detailed instructions for using the ACT program are given in Appendix A. These instructions have been extracted from Reference 14 because of the importance of having proper aerodynamic coefficient tables for the successful execution of GESS.

4.3 Simulation Input Variables

Prior to running the GESS program, an 80 column card image input file must be created. This file consists of START and STOP cards, a three card headers, and fifteen data sections. A sample listing of a typical input file is given in Appendix B.

The program can be run against several sets of data without the user having to resubmit the job. This is accomplished by placing the START card at the beginning of each input set so that the input sets are separated by START cards. A STOP or blank card is placed at the end of the entire input file. The job is terminated when the program reaches this instruction.

The three line header is used to identify the input file, as well as all subsequent output reports. Any alphanumerical data may be entered, but the third line serves to identify the seat to be simulated. If three lines (or records) of description are not necessary, then blank records must be inserted to complete the mandatory three lines. Each of the fifteen data sections contain a specific number of variables or arrays depending upon the section requirements. Each variable occupies a 20 column field comprised of a 10 column alphanumeric descriptor space and a 10 column integer or floating point data space. The descriptor space is provided for the user's convenience, and is usually used to enter the variable name. The descriptor is typically left-justified with any remaining spaces filled with blanks. The data space is always located to the right of its descriptor space, and should be right-justified in the designated format.

The variable fields are arranged within the data sections in records (or lines) of from one to four fields per record. The individual section requirements for field arrangement are discussed in each of the following subsections.

The GESS program performs a series of checks on the input variables to ensure that the data given will be compatible with the program logic. When problems with the given data are determined, descriptive error messages are printed. These messages will describe the problem as either a "Warning" or a "Fatal Error". Warning messages allow the program to continue, but fatal errors will halt execution, and must be corrected and resubmitted. Both types of messages include a description of the problem encountered.

4.3.1 Program Controls. The Program Control section allows the user to control the execution of the simulation. Variable fields are arranged as shown in Figure 4-1.

DOWHAT			
[HEADER]			
TSTART,	TSTOP,	ESTOP,	IRESTRT
IUNITS,	ISEATTR,	ISOSEP,	IPLOT
IDRIFLG			

Figure 4-1. Program Control Variable Fields

These variables are described in Table 4-1.

Table 4-1. Program Control Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
DOWHAT	Input delimiter variable ("START"-beginning of new input deck) ("STOP"-end of job) ([blank card]-same as "STOP")	A5	N/A
HEADER	Simulation identifier (any relevant 3 lines of alphanumerics)	3(8A10)	N/A
TSTART	Time at which simulation starts (0.0-normal start) (>0.0-restart)	F10.4	sec
TSTOP	Time at which simulation stops (0.0-stop at event ESTOP) (>0.0-stop at time TSTOP)	F10.4	sec
ESTOP	Event at which simulation stops (0-stops a time TSTOP) (1-catapult 1 ignition) (2-catapult 2 ignition) (3-catapult 1 separation) (4-catapult 2 separation) (5-rail separation) (6-rocket 1 ignition) (7-rocket 2 ignition) (8-rocket 3 ignition) (9-rocket 4 ignition) (10-rocket 5 ignition) (11-rocket 6 ignition) (12-rocket 1 burnout) (13-rocket 2 burnout) (14-rocket 3 burnout) (15-rocket 4 burnout) (16-rocket 5 burnout) (17-rocket 6 burnout) (18-drogue chute 1 deployment) (19-drogue chute 1 line stretch) (10-drogue chute 1 full inflation) (21-drogue chute 2 deployment) (22-drogue chute 2 line stretch) (23-drogue chute 2 full inflation) (24-recovery chute deployment) (25-recovery chute line stretch) (26-recovery chute full inflation) (27-peak trajectory) (28-seat/occupant separation) (29-seat/occupant impact) (30-occupant impact)	I2	N/A

(Continued)

Table 4-1. Program Control Variable Descriptions (Continued)

Variable	Definition (Legal Values)	Format	Units
ESTOP (Continued)			
	(31-seat impact) (32-aircraft impact) (33-DART right line start) (34-DART left line start) (35-DART right line broken) (36-DART left line broken) (37-seat separation from aircraft) (38-seat first motion)		
IRESTRT	Instantaneous restart flag, to create a data base of all trajectory information at a specified time from which multiple continuations can be made (0-restart file not created) (1-not implemented)	I2	N/A
IUNITS	Flag controlling units of measure (0-metric units) (1-English units)	I2	N/A
ISEATTR	Flag controlling seat alone trajectory (0-trajectory not generated) (1-trajectory generated)	I2	N/A
ISOSEP	Flag controlling seat/occupant separation (0-separation suppressed) (1-separation based on time) (2-separation based on force)	I2	N/A
IPLOT	Flag controlling plot file generation (0-plot file not generated) (1-plot file generated)	I2	N/A
IDRIFLG	Flag controlling Dynamic Response Index Calculation (0-DRI not generated) (1-DRI generated)	I2	N/A

4.3.2 Report Flags. The Report Flags section allows the user to select the output reports that will be required for the specific analyses to be conducted. Variable fields are arranged as shown in Figure 4-2.

```
IREPTS(1),     IREPTS(2),     IREPTS(3),     IREPTS(4)
IREPTS(5),     IREPTS(6),     IREPTS(7),     IREPTS(8)
                                  .
                                  .
                                  .
IREPTS(29),    IREPTS(30),    IREPTS(31)
```

Figure 4-2. Report Flag Variable Fields

These variables are described in Table 4-2.

Table 4-2. Report Flags Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IREPTS(i)	Flag controlling report i generator (0-report i not generated) (1-report i generated)	I2	N/A

Refer to Table 5-1 for report titles.

4.3.3 Integration Time Steps. The Integration Time Steps section allows the user to adjust the time increments between trajectory phases. The precision of the trajectory is inversely affected by the size of the time steps; hence, a larger time step, although more economical in terms of computer time, can result in greater inaccuracies in the integration calculations. The simulation has been categorized into three phases:

- Phase I - from Time = 0 to Seat/Aircraft Separation
- Phase II - from S/A Separation to Seat/Occupant Separation
- Phase III - from S/O Separation to Occupant Impact

It is recommended that the earlier phases have very small time increments, since this period is characterized by very complex forces and moments, while later phases have larger time increments to conserve computer time. The variable fields in this section are arranged as shown in Figure 4-3.

PI1,	PI2,	PI3
DTPHAS1,	DTPHAS2,	DTPHAS 3

Figure 4-3. Integration Time Step Variable Fields

These variables are described in Table 4-3.

Table 4-3. Integration Time Step Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
PI1	Print frequency - Phase 1	I4	N/A
PI2	Print frequency - Phase 2	I4	N/A
PI3	Print frequency - Phase 3 (PIi > 0)	I4	N/A
DTPHAS1	Integration time step - Phase 1	F10.4	sec
DTPHAS2	Integration time step - Phase 2	F10.4	sec
DTPHAS3	Integration time step - Phase 3 (DTPHASi > 0)	F10.4	sec

4.3.4 Initial Conditions

The Initial Conditions section allows the user to create the precise escape scenario required for analysis. Variable fields are arranged as shown in Figure 4-4.

```
TEMP,         PRESSUR,      DENSITY
XPOS,         YPOS,         ZPOS
YAW,          PITCH,        ROLL
RVEL,         QVEL,         PVEL
WINDX,        WINDY,        WINDZ
XACVEL,       ZACVEL,       CKPITHT
NPTSAAT,
AAT(1,1),     AAT(1,2),     AAT(1,3),     AAT(1,4)    ┐
                 .                                    │
                 .                                    ├─ See Section
                 .                                    │  4.3.4.1
AAT(50,1),    AAT(50,2),    AAT(50,3),    AAT(50,4)   ┘
NPTSLAT
LAT(1,1),     LAT(1,2),     LAT(1,3),     LAT(1,4)    ┐
                 .                                    │
                 .                                    ├─ See Section
                 .                                    │  4.3.4.2
LAT(50,1),    LAT(50,2),    LAT(50,3),    LAT(50,4)   ┘
```

Figure 4-4. Initial Condition Variable Fields

These variables are described in Table 4-4.

Table 4-4. Initial Conditions Variable Descriptions

Variable	Definition (Legal Values)	Format	Units Engl.(metr.)
TEMP	Air temperature	F10.4	°F(°C)
PRESSUR	Barometric pressure(>0.0)	F10.4	millibars
DENSITY	Atmospheric density or mass/unit volume (>0.0) (0.0-effective density calculated from TEMP)	F10.4	slugs/ft^3
XPOS	Initial aircraft X-position in EFCS	F10.4	ft(m)
YPOS	Initial aircraft Y-position in EFCS	F10.4	ft(m)
ZPOS	Initial aircraft Z-position in EFCS	F10.4	ft(m)
YAW	Initial aircraft yaw in EFCS	F10.4	deg
PITCH	Initial aircraft pitch in EFCS	F10.4	deg
ROLL	Initial aircraft roll in EFCS	F10.4	deg
RVEL	Initial angular velocity about aircraft Z-Axis, or yaw velocity	F10.4	deg/sec
QVEL	Initial angular velocity about aircraft Y-Axis, or pitch velocity	F10.4	deg/sec
PVEL	Initial angular velocity about aircraft X-Axis, or roll velocity	F10.4	deg/sec
WINDX	Wind X-velocity in EFCS	F10.4	ft/sec (m/sec)
WINDY	Wind Y-velocity in EFCS	F10.4	ft/sec (m/sec)
WINDZ	Wind Z-velocity in EFCS	F10.4	ft/sec (m/sec)
XACVEL	Initial aircraft X-velocity in EFCS (>0.0)	F10.4	ft/sec (m/sec)
ZACVEL	Initial vertical rate of climb in EFCS or sink rate	F10.4	ft/sec (m/sec)
CKPITHT	Aircraft cockpit screen height in ACS or protected height of seat/occupant (>0.0)	F10.4	ft/sec (m/sec)
NPTSAAT	Number of points in aircraft angular acceleration table (0-50)	I3	N/A
AAT(i,j)	Aircraft angular acceleration table array (See Section 4.3.4.1)	i(4F10.4)	sec,deg/sec^2
NPTSLAT	Number of points in aircraft linear acceleration table (0-50)	I3	N/A
LAT(i,j)	Aircraft linear acceleration table array	i(4F10.4)	sec,ft/sec^2 (sec,m/sec^2)

4.3.4.1. If NPTSAAT = 0, no AAT values are given. When 1 < NPTSAAT < 50, NPTSAAT lines of AAT values must be entered. Each line of AAT data consists of the time at which that line of data is initialized (AAT(i,1)), followed by the X, Y, and Z values of the angular acceleration (AAT(i,2), AAT(i,3), and AAT(i,4), respectively). The GESS program linearly interpolates the values between points based on the time value. Hence, a typical aircraft angular acceleration table could be set up as follows:

NPTSAAT	5						
AAT(1,1)	0.000	AAT(1,2)	0.0	AAT(1,3)	5.0	AAT(1,4)	0.0
AAT(2,1)	2.999	AAT(2,2)	0.0	AAT(2,3)	5.0	AAT(2,4)	0.0
AAT(3,1)	3.000	AAT(3,2)	0.0	AAT(3,3)	-5.0	AAT(3,4)	0.0
AAT(4,1)	5.999	AAT(4,2)	0.0	AAT(4,3)	-5.0	AAT(4,4)	0.0
AAT(5,1)	6.000	AAT(5,2)	0.0	AAT(5,3)	0.0	AAT(5,4)	0.0

4.3.4.2. The LAT array is set up identically to the AAT array, based on NPTSLAT. Hence, a typical aircraft linear acceleration table could be set up as follows:

NPTSLAT	2						
LAT(1,1)	0.000	LAT(1,2)	0.0	LAT(1,3)	0.0	LAT(1,2)	-32.2
LAT(2,1)	30.000	LAT(2,1)	0.0	LAT(2,3)	0.0	LAT(2,1)	-32.2

4.3.5 <u>Seat Alone Descriptors</u>. The Seat Alone section allows the user to fully describe all aspects of the various escape system ejection seats. Variable fields are arranged as shown in Figure 4-5.

XPOSSRP,	YPOSSRP,	ZPOSSRP
XCGSA,	YCGSA,	ZCGSA
IXXSA,	IXYSA,	IXZSA
IYYSA,	IYZSA,	IZZSA
PHISA,	PSISA,	THESA
AREASA,	HGHTSA,	WGHTSA
XPOSBOT,	YPOSBOT,	ZPOSBOT
XPOSSCS,	YPOSSCS,	ZPOSSCS

Figure 4-5. Seat Alone Variable Fields

These variables are described in Table 4-5.

Table 4-5. Seat Alone Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
XPOSSRP	X position of seat alone aerodynamics reference point	F10.4	ft(m)
YPOSSRP	Y position of seat alone aerodynamics reference point	F10.4	ft(m)
ZPOSSRP	Z position of seat alone aerodynamics reference point	F10.4	ft(m)
XCGSA	X position of seat alone center of gravity in SCS	F10.4	ft(m)
YCGSA	Y position of seat alone center of gravity in SCS	F10.4	ft(m)
ZCGSA	Z position of seat alone center of gravity in SCS	F10.4	ft(m)
IXXSA	Seat alone moment of inertia about X-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IXYSA	Seat alone moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IXZSA	Seat alone moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IYYSA	Seat alone moment of inertia about Y-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IYZSA	Seat alone moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IZZSA	Seat alone moment of inertia about Z-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
PHISA	Angular position of seat alone about ACS X-axis	F10.4	deg
PSISA	Angular position of seat alone about ACS Y-axis	F10.4	deg
THESA	Angular position of seat alone about ACS Z-axis	F10.4	deg
AREASA	Aerodynamic reference area of seat alone (>0.0)	F10.4	ft^2(m^2)
HGHTSA	Height or vertical length of seat alone (>0.0)	F10.4	ft(m)
WGHTSA	Weight of seat alone after occupant separation (>0.0)	F10.4	lbs(kg)
XPOSBOT	X-position of seat bottom in RCS	F10.4	ft(m)
YPOSBOT	Y-position of seat bottom in RCS	F10.4	ft(m)
ZPOSBOT	Z-position of seat bottom in RCS	F10.4	ft(m)
XPOSSCS	X-position of SCS origin in RCS	F10.4	ft(m)
YPOSSCS	Y-position of SCS origin in RCS	F10.4	ft(m)
ZPOSSCS	Z-position of SCS origin in RCS	F10.4	ft(m)

4.3.6 __Seat/Occupant Descriptors.__ The Seat/Occupant section allows the user to fully describe all aspects of the seat/occupant combination. Variable fields are arranged as shown in Figure 4-6.

XCGSO,	YCGSO,	ZCGSO
IXXSO,	IXYSO,	IXZSO
IYYSO,	IYZSO,	IZZSO
AREASO,	WGHTSO	

Figure 4-6. Seat/Occupant Variable Fields

These variables are described in Table 4-6.

Table 4-6. Seat/Occupant Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
XCGSO	X-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
YCGSO	Y-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
ZCGSO	Z-position of seat/occupant center of gravity in SCS	F10.4	ft(m)
IXXSO	Seat/occupant moment of inertia about X-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IXYSO	Seat/occupant moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IXZSO	Seat/occupant moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IYYSO	Seat/occupant moment of inertia about Y-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IYZSO	Seat/occupant moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
IZZSO	Seat/occupant moment of inertia about Z-axis (>0.0)	F10.4	slug-ft^2 (kg-m^2)
AREASO	Aerodynamic reference area of seat/occupant (>0.0)	F10.4	ft^2(m^2)
WGHTSO	Weight of seat/occupant combination (>0.0)	F10.4	lbs(kg)

4.3.7 Occupant Alone Descriptors. The Occupant Alone section allows the user to fully describe the basic features of the occupant before and after separation from the ejection seat. Variable fields are arranged as shown in Figure 4-7.

IXXOA,	IXOYA,	IXZOA
IYYOA,	IYZOA,	IZZOA
AREAOAA,	WGHTOAB,	WGHTOAA
SOSEP,	DMPGC	

Figure 4-7. Occupant Alone Variable Fields

These variables are described in Table 4-7.

Table 4-7. Occupant Alone Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IXXOA*	Occupant alone moment of inertia about X-axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})
IXYOA*	Occupant alone moment of inertia about X-Y translational axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})
IXZOA*	Occupant alone moment of inertia about X-Z translational axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})
IYYOA*	Occupant alone moment of inertia about Y-axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})
IYZOA*	Occupant alone moment of inertia about Y-Z translational axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})
IZZOA*	Occupant alone moment of inertia about Z-axis (>0.0)	F10.4	slug-ft ^{2} (kg-m ^{2})

(continued)

* - Input required, although not currently used in program.

Table 4-7. Occupant Alone Variable Descriptions
(Continued)

AREAOAA	Aerodynamic reference area of occupant alone after separation from seat (>0.0)	F10.4	$ft^2(m^2)$
WGHTOAB	Weight of occupant alone before separation from seat (>0.0) see Section 4.3.7.1	F10.4	lbs(kg)
WGHTOAA	Weight of occupant alone after separation from seat (>0.0) see Section 4.3.7.1	F10.4	lbs(kg)
SOSEP	Seat/occupant separation parameter (>0.0) see Section 4.3.7.2	F10.4	sec;lbs (sec;kg)
DMPGC	Aerodynamic angular damping coefficient (0.0<DMPGC<1.0)	F10.4	N/A

4.3.7.1. After seat/occupant separation, the weight of the occupant alone includes the weight of the parachute pack and all emergency gear. Before separation, this extra weight is considered part of the seat.

4.3.7.2. SOSEP determines the point at which seat/occupant separation occurs. It does this conditionally, depending upon the means being used to determine separation dictated by ISOSEP in Section 1. Hence, if ISOSEP=1, then SOSEP will be the time at which separation occurs. Alternately, if ISOSEP=2, then SOSEP will be the recovery chute force required to produce separation.

4.3.8 <u>Rail Data</u>. The Rail Data section allows the user to fully describe all aspects of the seat/aircraft rail system. Variable fields are arranged as shown in Figure 4-8.

```
RAILNTH,        RAILANG
ISTRL,          NSLBKS
KXSB,           KYSB,          MUSB
YKTOR,
XPOSRRE,        YPOSRRE,       ZPOSRRE
XPOSSLRE,       YPOSLRE,       ZPOSLRE
XPOSSB(1),      YPOSSB(1),     ZPOSSB(1)
   .               .              .          See Section
   .               .              .          4.3.8.1
   .               .              .
XPOSSB(6),      YPOSSB(6)      ZPOSSB(6)
```

Figure 4-8. Rail Data Variable Fields

These variables are described in Table 4-8.

Table 4-8. Rail Data Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
RAILNTH	Length of rails (>0.0)	F10.4	ft(m)
RAILANG	Pitch angle of rails WRT ACS X-Axis	F10.4	deg
ISTRL	Slider block flag (0-slipper/slider blocks are on seat) (1-slipper/slider blocks are on aircraft)	I3	N/A
NSLBKS	Number of slipper/slider blocks (0-6)	I3	N/A
KXSB	Effective rail spring constant along RCS X-axis(>0.0)	F10.6	lbs/ft (N/m)
KYSB	Effective rail spring constant along RCS Y-axis(>0.0)	F10.6	lbs/ft (N/m)
MUSB	Rail to slider block coefficient of friction (>0.0)	F10.6	N/A
YKTOR	Effective torsional spring constant along RCS Y-axis(>0.0)	F10.6	ft-lbs/deg (N-m/deg)
XPOSRRE	Right rail attachment point along ACS X-axis	F10.4	ft(m)
YPOSRRE	Right rail attachment point along ACS Y-axis	F10.4	ft(m)
ZPOSRRE	Right rail attachment point along ACS Z-axis	F10.4	ft(m)
XPOSLRE	Left rail attachment point along ACS X-axis	F10.4	ft(m)
YPOSLRE	Left rail attachment point along ACS Y-axis	F10.4	ft(m)
ZPOSLRE	Left rail attachment point along ACS Z-axis	F10.4	ft(m)
XPOSSB(i)	Slippe./Slider block i X-position in SCS	F10.4	ft(m)
YPOSSB(i)	Slipper/Slider block i Y-position in SCS	F10.4	ft(m)
ZPOSSB(i)	Slipper/Slider block i Z-position in SCS (see Section 4.3.8.1)	F10.4	ft(m)

4.3.8.1. If NSLBKS = 0, then the GESS program assumes that a continuous "rail within a rail", with no slippers or slider blocks, is being used; the KPOSSB, YPOSSB, and ZPOSSB arrays are not inputted. Otherwise, each of the NSLBKBS slider blocks is located by a separate line of XPOSSB, YPOSSB, and ZPOSSB data.

4.3.9 Catapult Data. The Catapult section allows the user to fully describe all aspects of the in-aircraft catapult seat launching system. Variable fields are arranged as shown in Figure 4-9.

INCAT

See Section 4.3.9.1

CATLNT(1), CATSTK(1), TCI(1)

XPOSAP(1), YPOSAP(1), ZPOSAP(1)

NPTSCT(1)

See Section 4.3.9.2

CATHRST(1,1,1),CATHRST(1,1,2),CATHRST(1,2,1),CATHRST(1,2,2)

.

.

.

CATHRST(1,25,1),CATHRST(1,25,2)

See Section 4.3.9.1

CATLNT(2), CATSTK(2), TCI(2)

XPOSAP(2), YPOSAP(2), ZPOSAP(2)

NPTSCT(2)

See Section 4.3.9.2

CATHRST(2,1,1),CATHRST(2,1,2),CATHRST(2,2,1),CATHRST(2,2,2)

.

.

.

CATHRST(2,25,1),CATHRST(2,25,2)

See Section 4.3.9.3

ITUBEND

KTUBE, CTUBE, PTUBE

MUTUBE, EXTLNGT

Figure 4-9. Catapult Variable Fields

These variables are described in Table 4-9.

Table 4-9. Catapult Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
INCAT	Number of catapults (0-2)	I3	N/A
CATLNT(i)	Length of catapult i tube (>0.0)	F10.4	ft(m)
CATSTK(i)	Length of catapult i stroke (>0.0)	F10.4	ft(m)
TCI(i)	Catapult i time of ignition (>0.0)	F10.4	sec
XPOSAP(i)	Catapult i attachment point on SCS X-axis	F10.4	ft(m)
YPOSAP(i)	Catapult i attachment point on SCS Y-axis	F10.4	ft(m)
ZPOSAP(i)	Catapult i attachment point on SCS Z-axis	F10.4	ft(m)
NPTSCT(i)	Number of points in catapult i thrust table	I3	N/A
CATHRST(i,j,1)	Catapult i thrust table point; time (>0.0)	F10.4	sec
CATHRST(i,j,2)	Catapult i thrust table point; thrust (>0.0)	F10.4	lbs(N)
ITUBEND	Flag to simulate catapult tube bending (0-no tube bending) (1-tube bending using default values) (2-tube bending using input values)	I3	N/A
KTUBE	Tube spring stiffness constant K (>0.0)	F10.4	lb/ft (N/m)
CTUBE	Tube spring damping coefficient K (>0.0)	F10.4	lb-sec/ft (N-sec/m)
PTUBE	Empirical tube bending constant (>0.0)	F10.4	N/A
MUTUBE	Coefficient of friction (>0.0)	F10.4	N/A
EXTLNGT	External length of catapult tube (>0.0)	F10.4	ft(m)

4.3.9.1. Should INCAT=0, then catapults will not be simulated, and no further data is required in this section. If INCAT=1, then one catapult will be simulated, requiring only that catapult's data subsection and the tube bending subsection, if applicable. If INCAT=2, then applicable all data subsections will be required.

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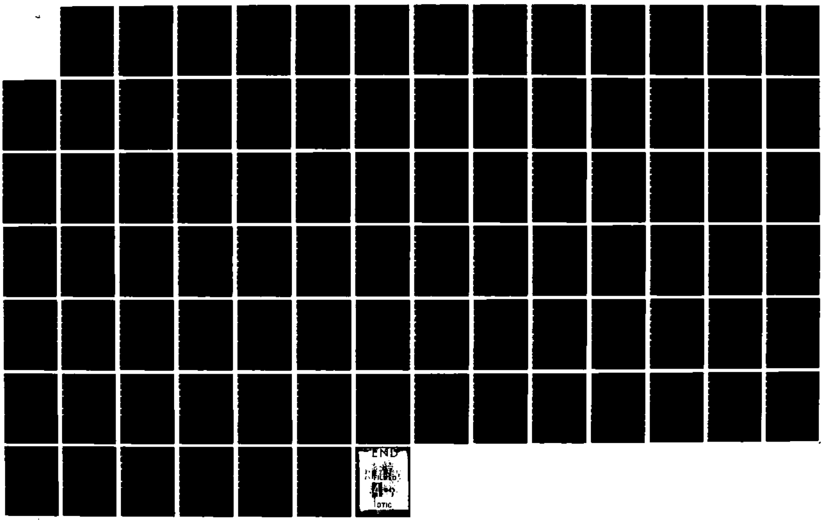

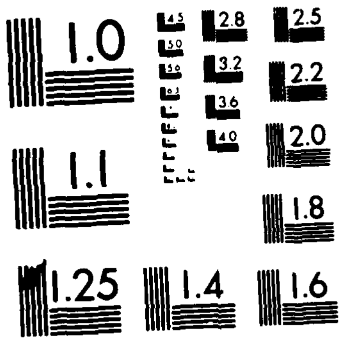

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

4.3.9.2. If NPTSCT(i) = 0, then no CATHRST data is required. Otherwise, two CATHRST array values (time and thrust) will be required for each NPTSCT(i) point, arranged in lines of four values each.

4.3.9.3. If ITUBEND=0 or 1, then no further tube bending data is required. If ITUBEND=2, then the five tube bending variables must be entered as indicated.

4.3.10 Rocket Data. The Rocket section allows the user to fully describe all aspects of the ejection seat booster rockets. Variable fields are arranged as shown in Figure 4-10.

4.3.10.1. If INRKT=0, then rockets will not be simulated, and no further data is required in this section.

4.3.10.2. If INRKT > 0, then INRKT represents the number of rocket data subsections required, each describing one of up to six rockets.

4.3.10.3. At least two rocket thrust table points must be given for each rocket subsection. Each point consists of a time value and the thrust at that time. The GESS program linearly interpolates between points based on time.

4.3.10.4. The rocket thrust angles are the direction cosines of the thrust vector with respect to the seat coordinate system. The thrust in each direction is computed by the program based on the total thrust multiplied by the cosines of the rocket angles.

```
INRKT

RKIGN(1),      RKWGHT(1),      RKBURN(1),      RKDELY(1)

XPOSRK(1),     YPOSRK(1),      ZPOSRK(1)
                                                                See Section
RKALPH(1),     RKBETA(1),      RKGAMA(1)                         4.3.10.1

RKNPTS(1)                                                       See Section
                                                                 4.3.10.2
RKTHRST(1,1,1),RKTHRST(1,1,2),RKTHRST(1,2,1),RKTHRST(1,2,2)
                                                                See Section
                    .                                            4.3.10.3

                    .

                    .

RKTHRST(1,25,1),RKTHRST(1,25,2)

                    .

                    .

                    .

RKIGN(6),      RKWGHT(6),      RKBURN(6),      RKDELY(6)

XPOSRK(6),     YPOSRK(6),      ZPOSRK(6)

RKALPH(6),     RKBETA(6),      RKGAMA(6)                        See Section
                                                                4.3.10.2
RKNPTS(6)

RKTHRST(6,1,1),RKTHRST(6,1,2),RKTHRST(6,2,1),RKTHRST(6,2,2)
                                                                See Section
                    .                                           4.3.10.3

                    .

                    .

RKTHRST(6,25,1),RKTHRST(6,25,2)
```

Figure 4-10. Rocket Variable Fields

These variables are described in Table 4-10.

Table 4-10. Rocket Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
INKRT	Number of booster rockets on seat (0-6)	I3	N/A
RKIGN(i)	Seat travel on rail prior to rocket i ignition (>0.0)	F10.4	ft(m)
RKWGHT(i)	Weight of fuel in rocket i (>0.0)	F10.4	lbs(kg)
RKBURN(i)	Burn time for rocket i (>0.0)	F10.4	sec
RKDELY(i)	Delay time for rocket i ignition after RKIGN(i)(>0.0)	F10.4	sec
XPOSRK(i)	Position of rocket i in SCS X-axis	F10.4	ft(m)
YPOSRK(i)	Position of rocket i in SCS Y-axis	F10.4	ft(m)
ZPOSRK(i)	Position of rocket i in SCS Z-axis	F10.4	ft(m)
RKALPH(i)	Thrust angle of rocket i WRT SCS X-axis	F10.4	deg*
RKBETA(i)	Thrust angle of rocket i WRT SCS Y-axis	F10.4	deg*
RKGAMA(i)	Thrust angle of rocket i WRT SCS Z-axis	F10.4	deg*
RKNPTS(i)	Number of points in rocket i thrust table (2-25)	I3	N/A
RKTHRST(i,j,1)	Rocket i thrust table point j time (>0.0)	F10.4	sec
RKTHRST(i,j,2)	Rocket i thrust table point j thrust (>0.0)	F10.4	lbs(N)

* See Section 4.3.10.4.

4.3.11 Drogue Chute Data. The Drogue Chute section allows the user to describe the drogue chute system. Variable fields are arranged as shown in Figure 4-11.

4.3.11.1. If IDROGUE=0, then no further information is required in this section.

4.3.11.2. If IDROGLS=1, then this subsection is not required.

4.3.11.3. If IDROGLS=0, then this subsection is not required.

4.3.11.4. Two values are required for each line stretch table point specified by NPTSDLS. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

4.3.11.5. If IFTDRO1=0, then no further information is required in this subsection.

4.3.11.6. Two values are required for each line stretch table point specified by NPTDRO1. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

4.3.11.7. If IDROGUE < 3, then no information is required in this subsection.

4.3.11.8. If IFTDRO2=0, then no further information is required in this subsection.

4.3.11.9. Two values are required for each line stretch table point specified by NPTDRO2. These points are arranged in the order of ascending velocities with up to two points (or four values) per line.

```
IDROGUE
                                                     See Section
TDDPLOY,     DISPLOY,     DROGLL                     4.3.11.1
DRDRAG1,     DROGPD1,     POROSD1
AREADC,      WGHTDC,      CDDC
XDROGAP,     YDROGAP,     ZDROGAP
IDROGLS
                                                     See Section
DROVELX,     DROVELY,     DROVELZ                    4.3.11.2
NPTSDLS
DROGLS(1,1),  DROGLS(1,2), DROGLS(2,1),DROGLS(2,2)
                                                     See Section
                  .                                  4.3.11.3
                  .
                  .                                  See Section
                                                     4.3.11.4
DROGLS(25,1), DROGLS(25,2)
IFTDRO1
NPTDFT1
DROGFT1(1,1), DROGFT1(1,2),DROGFT1(2,1),DROGFT1(2,2)  See Section
                                                     4.3.11.5
                  .
                  .                                  See Section
                  .                                  4.3.11.6
DROGFT1(25,1),DROGFT1(25,2)
VELCON
DRDRAG2      DROGPD2,     POROSD2
                                                     See Section
IFTDRO2                                              4.3.11.7
NPTDFT2
                                                     See Section
DROGFT2(1,1), DROGFT2(1,2),DROGFT2(2,1),DROGFT2(2,2)  4.3.11.8
                  .
                  .                                  See Section
                  .                                  4.3.11.9
DROGFT2(25,1),DROGFT2(25,2)
```

Figure 4-11. Drogue Chute Variable Fields

These variables are described in Table 4-11.

Table 4-11. Drogue Chute Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IDROGUE	Drogue chute control flag (0-do not simulate drogue chute) (1-simulate standard single drogue chute) (2-simulate VELCON/duplex drogue system)	I3	N/A
TDDPLOY	Time of drogue chute deployment (>0.0)	F10.4	sec
DISPLOY	Seat rail travel required for drogue chute deployment (>0.0)	F10.4	ft(m)
DROGLL	Drogue chute line length (>0.0)	F10.4	ft(m)
DRDRAGi	Drogue chute i drag coefficient (>0.0)	F10.4	N/A
DROGPDi	Drogue chute i projected diameter (>0.0)	F10.4	ft(m)
POROSDi	Drogue chute i effective porosity (>0.0)	F10.4	N/A
AREADC	Drogue container/slug reference area (>0.0)	F10.4	$ft^2(m^2)$
WGHTDC	Drogue container/slug weight (>0.0)	F10.4	lb(kg)
CDDC	Drogue container/slug drag coefficient (>0.0)	F10.4	N/A
XDROGAP	Drogue chute attachment point along SCS X-axis	F10.4	ft(m)
YDROGAP	Drogue chute attachment point along SCS Y-axis	F10.4	ft(m)
ZDROGAP	Drogue chute attachment point along SCS Z-axis	F10.4	ft(m)
IDROGLS	Drogue chute time of line stretch control flag (0-use slug/container projection velocity)* (1-use input table data)	I3	N/A
DROVELX	Drogue container/slug projection velocity in SCS X-axis	F10.4	ft/sec (m/sec)
DROVELY	Drogue container/slug projection velocity in SCS Y-axis	F10.4	ft/sec (m/sec)
DROVELZ	Drogue container/slug projection velocity in SCS Z-axis	F10.4	ft/sec (m/sec)
NPTSDLS	Number of points in drogue chute line stretch table (2-25)	I3	N/A

(continued)

*See Section 4.3.11.2 and 4.3.11.3

Table 4-11. Drogue Chute Variable Descriptions (Continued)

Variable	Definition (Legal Values)	Format	Units
DROGLS(i,1)	Drogue chute line stretch table point i velocity (>0.0)	F10.4	ft/sec (m/sec)
DROGLS(i,2)	Drogue chute line stretch table point i time (>0.0)	F10.4	sec
IFTDROi	Drogue chute i fill time control flag (0-use default table data) (1-use input table data)	I3	N/A
NPTDFTi	Number of points in drogue i fill time table (2-25)	I3	N/A
DROGFTi(j,1)	Drogue chute i fill time table point j velocity (>0.0)	F10.4	ft/sec (m/sec)
DROGFTi(j,2)	Drogue chute i fill time table point j time (>0.0)	F10.4	sec
VELCON	Seat velocity at which VELCON drogue chute disengages (>0.0)	F10.4	ft/sec (m/sec)

4.3.12 <u>Recovery Chute Data</u>. The Recovery Chute section allows the user to describe the recovery parachute system. Variable fields are arranged as shown in Figure 4-12.

4.3.12.1. If IRECOV=0, then the recovery chute deployment is to be suppressed, and no further information is required in this section.

4.3.12.2. If NPTSRDT=1, then only the value of TRDPLOY is entered. If 1<NPTSRDT<25, then only the deployment time table array, RECOVDT, is entered.

4.3.12.3. Two values are required for each line stretch table point specified by NPTSRLS. These points are arranged in the order of ascending velocities, with up to two points (or four values) per line.

4.3.12.4. If IFTRECV=0 or 1, then no further information is required by this section.

4.3.12.5. Two values are required for each full inflation table point specified by IFTRECV. These points are arranged in the order of ascending velocities, with up to two points (or four values) per line.

4.3.13 <u>DART Data</u>. The Directional Automatic Realignment of Trajectory (DART) sections allows the user to fully describe all aspects of the DART stabilization system. Variable fields are arranged as shown in Figure 4-13.

```
IRECOV

RECOVLL,    RECDRAG

RECOVPD,    POROSR,                                       See Section
                                                          4.3.12.1
XRECAP,     YRECAP,     ZRECEP

CHALT1,     CHALT2,     GLIMIT

TDELAY

NPTSRDT

TRDPLOY

RECOVDT(1,1),RECOVDT(1,2),RECOVDT(2,1),RECOVDT(2,2)
            .
            .                                             See Section
            .                                             4.3.12.2
RECOVDT(25,1),RECOVDT(25,2)

NPTSRLS

RECOVLS(1,1),RECOVLS(1,2),RECOVLS(2,1),RECOVLS(2,2)
            .
            .                                             See Section
            .                                             4.3.12.3
RECOVLS(25,1),RECOVLS(25,2)

IFTRECV
                                                          See Section
NPTSRFT                                                   4.3.12.4

RECOVFT(1,1),RECOVFT(1,2),RECOVFT(2,1),RECOVFT(2,2)
            .                                             See Section
            .                                             4.3.12.5
            .
RECOVFT(25,1),RECOVFT(25,2)
```

Figure 4-12. Recovery Chute Variable Fields

These variables are described in Table 4-12.

Table 4-12. Recovery Chute Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IRECOV	Recovery chute control flag (0-do not simulate recovery chute) (1-simulate recovery chute with fixed time delay) (2-simulate recovery chute with time delay extended for exceeding GLIMIT)	I3	N/A
RECOVLL	Recovery chute line length (>0.0)	F10.4	ft(m)
RECDRAG	Recovery chute drag coefficient (>0.0)	F10.4	N/A
RECOVPD	Recovery chute projected diameter (>0.0)	F10.4	ft(m)
POROSR	Recovery chute effective porosity (>0.0)	F10.4	N/A
XRECAP	Recovery chute attachment point along SCS X-axis	F10.4	ft(m)
YRECAP	Recovery chute attachment point along SCS Y-axis	F10.4	ft(m)
ZRECAP	Recovery chute attachment point along SCS Z-axis	F10.4	ft(m)
CHALT1	Lower chute deployment altitude (>0.0)	F10.4	ft(m)
CHALT2	Upper chute deployment altitude (>CHALT1)	F10.4	ft(m)
GLIMIT	Acceleration limit in SCS Z-axis for chute deployment delay (>0.0)	F10.4	G
TDELAY	Recovery chute deployment delay time between CHALT1 and CHALT2 (>0.0)	F10.4	sec
NPTSRDT	Number of points in recovery chute deployment time table (1-25)	I3	N/A
TRDPLOY	Time at which recovery chute is deployed (>0.0)	F10.4	sec
NPTSRLS	Number of points in recovery chute line stretch table (2-25)	I3	N/A
RECOVLS(i,1)	Recovery chute line stretch table point i velocity (>0.0)	F10.4	ft/sec (m/sec)
RECOVLS(i,2)	Recovery chute line stretch table point i time (>0.0)	F10.4	sec
IFTRECV	Recovery chute fill time control flag (0-use default table data) (1-use input table data)	I3	N/A
NPTSRFT	Number of points in recovery chute fill time table (2-25)	I3	N/A
RECOVFT(i,1)	Recovery chute fill time table point i velocity (>0.0)	F10.4	ft/sec (m/sec)
RECOVFT(i,2)	Recovery chute fill time table point i time (>0.0)	F10.4	sec

IDART			
DRTFRCE,	DRTSTRT,	DRSTOP	See Section 4.3.13.1
XDRTAP(1),	YDRTAP(1),	ZDRTAP(1)	
XDRTCP(1),	YDRTCP(1),	ZDRTCP(1)	
XDRTAP(2),	YDRTAP(2),	ZDRTAP(2)	
XDRTCP(2),	YDRTCP(2),	ZDRTCP(2)	

Figure 4-13. DART Variable Cards

These variables are described in Table 4-13.

Table 4-13. DART Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IDART	DART system flag (0-no DART system) (1-DART system)	I3	N/A
DRTFRCE	Force which the DART lines exert on the seat (>0.0)	F10.4	lbs(N)
DRTSTRT	Distance between seat and aircraft at which the DART initiates stabilization (>0.0)	F10.4	ft(m)
DRTSTOP	Distance between seat and aircraft at which the DART lines break (>DRTSTRT)	F10.4	ft(m)
XDRTAP(i)	DART line i cockpit attachment point along SCS X-axis	F10.4	ft(m)
YDRTAP(i)	DART line i cockpit attachment point along SCS Y-axis	F10.4	ft(m)
ZDRTAP(i)	DART line i cockpit attachment point along SCS Z-axis	F10.4	ft(m)
XDRTCP(i)	DART line i confluence point along SCS X-axis	F10.4	ft(m)
YDRTCP(i)	DART line i confluence point along SCS Y-axis	F10.4	ft(m)
ZDRTCP(i)	DART line i confluence point along SCS Z-axis	F10.4	ft(m)

4.3.13.1. If IDART=0, no further information is required in this section.

4.3.14 TVC Data. The Thrust Vector Control (TVC) section allows the user to implement and describe the response of a gimbaled booster rocket. Variable fields are arranged as shown in Figure 4-14.

ITVC			
MPHI,	MPSI,	MTHE	See Section 4.3.14.1
ROLLRL,	PITCHRL,	SMPLRAT	
TVCDLAY,	RKANG,		

Figure 4-14. TVC Variable Fields

These variables are described in Table 4-14.

Table 4-14. TVC Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
ITVC	Thrust vector control (TVC) flag (0-do not simulate TVC) (1-simulate TVC)	I3	N/A
MPHI	TVC coordinate system rotation about SCS X-axis	F10.4	deg
MPSI	TVC coordinate system rotation about SCS Y-axis	F10.4	deg
MTHE	TVC coordinate system rotation about SCS Z-axis	F10.4	deg
ROLLRL	Rocket rotation limit about TVCCS X-axis	F10.4	deg
PITCHRL	Rocket rotation limit about TVCCS Y-axis	F10.4	deg
SMPLRAT	Gyroscope maximum sampling rate (>0.0)	F10.4	deg/sec
TVCDLAY	TVC gimbaling time delay after rocket ignition (>0.0)	F10.4	sec
RKANG	Neutral rocket pitch angle in TVCCS	F10.4	deg

4.3.14.1. If ITVC=0, then no further information is required in this section.

4.3.15 Dynamic CG Data. The Dynamic Center of Gravity (CG) section allows the user to implement and describe the response of an occupant modeled as a single mass connected to the seat by a three-dimensional spring-damper system. Variable fields are arranged as shown in Figure 4-15.

```
IDYNCG
CX,       XSLACK,   SXP   ┐
SXN,      CY,       SY    │
CZ,       ZSLACK,   SZP   ├─ See Section 4.3.15.1
ZBOT,     SZNI,     SZN2  ┘
```

Figure 4-15. Dynamic CG Variable Fields

These variables are described in Table 4-15. Typical dynamic CG X, Y, and Z-axis spring constants are shown in Figures 4-16, -17, and -18.

Table 4-15. Dynamic CG Variable Descriptions

Variable	Definition (Legal Values)	Format	Units
IDYNCG	Dynamic CG flag (0-do not simulate dynamic CG) (1-simulate dynamic CG using default values) (2-simulate dynamic CG using input values)	I3	N/A
CX	Damping constant along SCS X-axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
XSLACK	No-response distance along SCS X-axis (>0.0)	F10.4	ft(m)
SXP	Spring constant along SCS positive X-axis (>0.0)	F10.4	lbs/ft (N/m)
SXN	Spring constant along SCS negative X-axis (>0.0)	F10.4	lbs/ft (N/m)
CY	Damping constant along SCS Y-axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
SY	Spring constant along SCS Y-axis (>0.0)	F10.4	lbs/ft (N/m)
CZ	Damping constant along SCS Z-Axis (>0.0)	F10.4	lbs-sec/ft (N-sec/m)
ZSLACK	No-response distance along SCS Z-axis (>0.0)	F10.4	ft(m)
SZP	Spring constant along SCS positive Z-axis (>0.0)	F10.4	lbs/ft (N/m)
ZBOT	Absolute value of bottoming distance along SCS Z-axis (>0.0)	F10.4	ft(m)
SZN1	Spring constant below ZBOT (>0.0)	F10.4	lbs/ft (N/m)
SZN2	Spring constant above ZBOT (>SZN1)	F10.4	lbs/ft (N/m)

4.3.15.1. If IDYNCG=0 or 1, then no further information is required in this section.

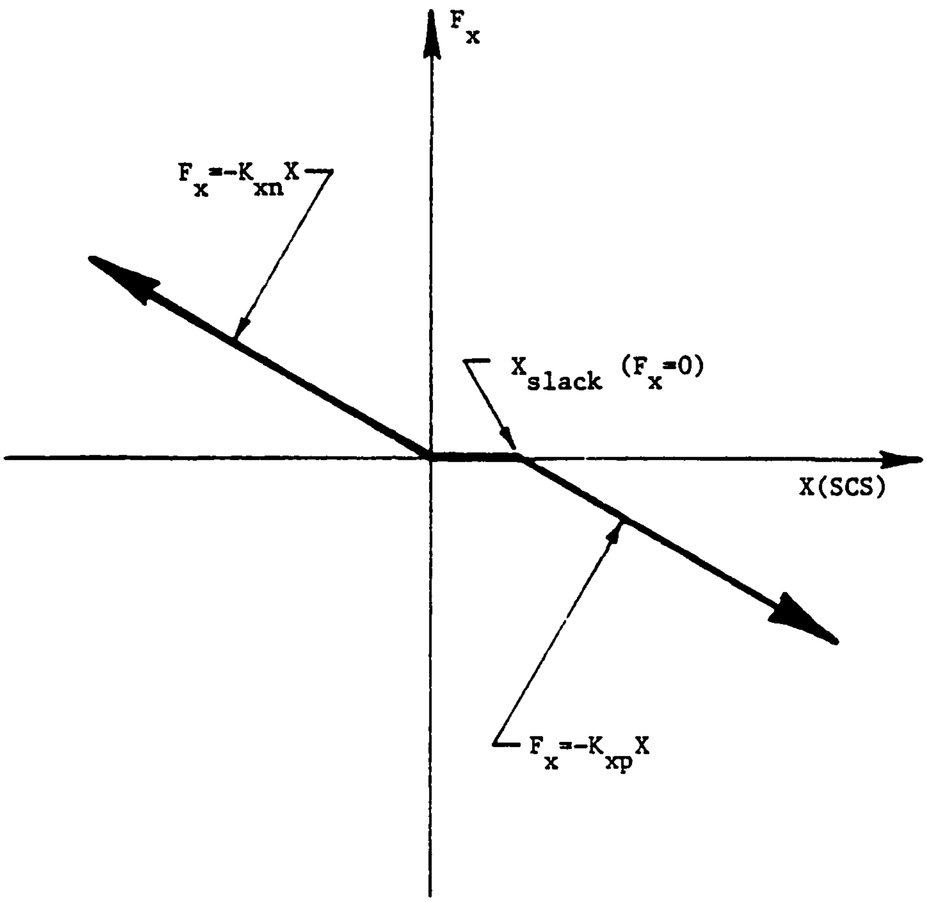

Figure 4-16. Dynamic CG X-Axis Spring Constants

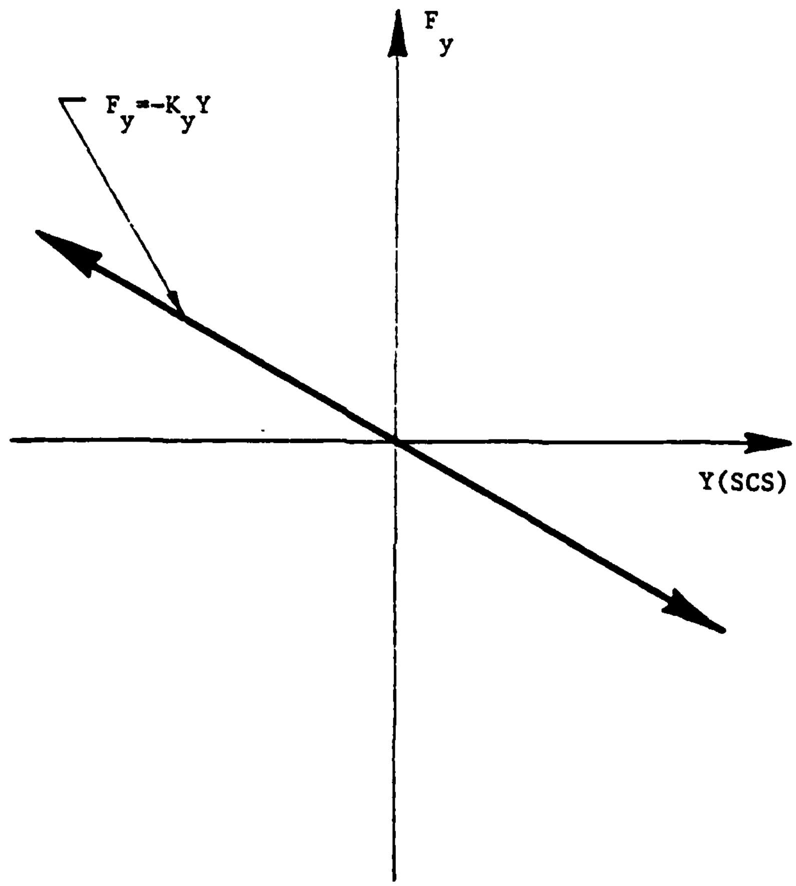

Figure 4-17. Dynamic CG Y-Axis Spring Constants

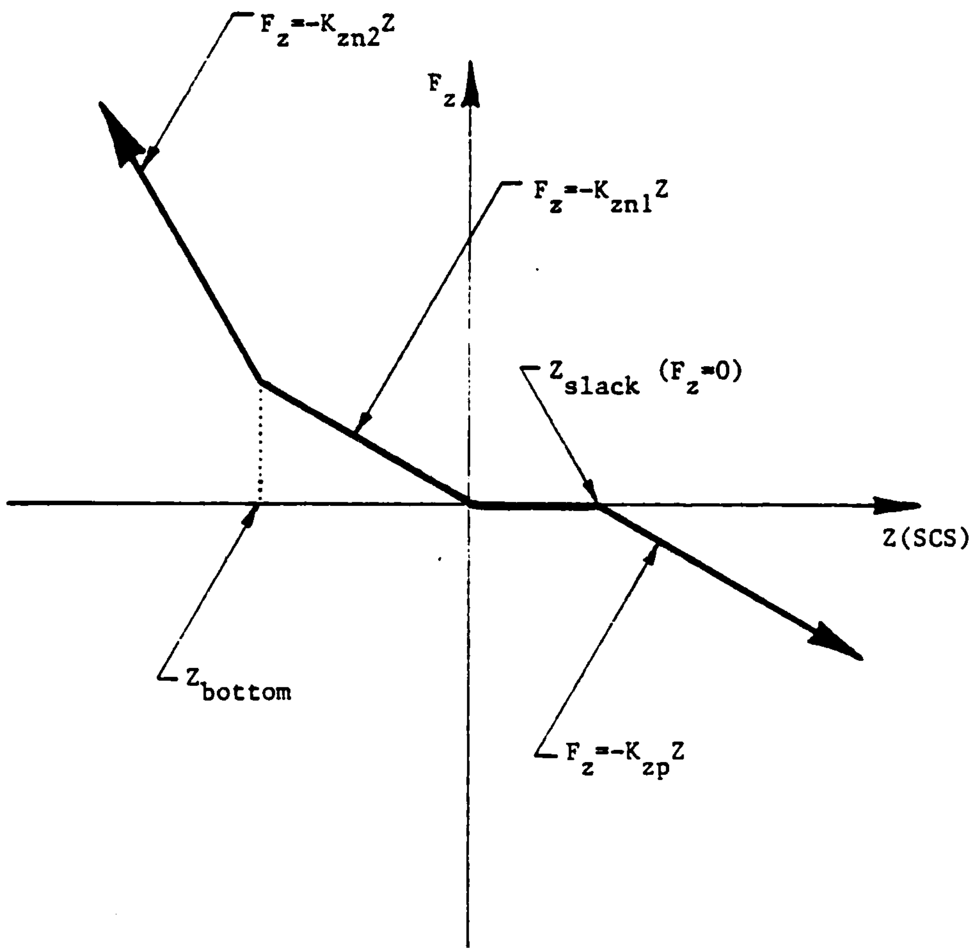

Figure 4-18. Dynamic CG Z-Axis Spring Constants

4.4 Execution Job Stream

The GESS program is executed by submitting to the computer a series of operating system commands known as the "job stream". The job stream can be entered line-by-line interactively. However, it is usually more convenient to prepare a job stream, or "submit file", in advance of execution and "batch" submit this file to the computer for execution. The interactive commands to batch submit a job stream are:

```
GET,filename
SUBMIT,filename
```

Another print site can be specified if the main computer center printer is not desired.

```
SUBMIT,filename, EI=print site identifier
```

If no printed output is desired:

```
SUBMIT,filename,N
```

Figure 4-18 presents a recommended job stream for GESS execution using the CDC KRONOS operating system. This job stream provides for:

- the loading of the prepared input file (GESSI)
- the loading of the ACT program-generated aerodynamic coefficient tables (AERO4)
- the loading and execution of the pre-compiled program binary code (GESSB)
- the optional creation or replacement of program-generated plotting data files (GESST and GESSZ)
- the creation of a single, inclusive, indirect access output file containing a mirror copy of the original input file and all requested program-generated reports (GESSO)

- A "day file" record of the submitted job execution (GESSDAY)
- An error recovery logic that saves the day file and any prior output, in the eventuality of an execution error

The recommended job stream is intended for execution runs generating a nominal number of output reports and/or simulating a relatively few seconds of simulated trajectory. Should a large number of reports and/or a long simulation period be desired, the output (and, possibly, the plotting files) should be created either as a direct access file, or as several indirect files. Refer to Reference 12 for details on direct file creation on the KRONOS system.

```
/JOB
GESS(CB200000,T75)
ACCOUNT(XXXXXX,YYYYYY)
ASSIGN,MS,OUTPUT
GET(TAPE1=KGESI)
GET(TAPE2=AERO4)
GET(GESSB)
MAP(OFF)
GESSB.
REPLACE(TAPE42=KGEST)
REPLACE(TAPE41=KGESZ)
GOTO,1.
EXIT.
1,REWIND,*.
SKIPF(DAYFILE)
COPYSBF(TAPE1,OUTPUT)
COPYBF(TAPE5,OUTPUT)
COPYBF(TAPE6,OUTPUT)
COPYBF(TAPE7,OUTPUT)
    .
    .
    .
COPYBF(TAPE40,OUTPUT)
REWIND,OUTPUT.
REPLACE(OUTPUT=KGESO)
GOTO,2.
EXIT.
2,DAYFILE,GESSDAY.
REPLACE,GESSDAY.
EXIT.
/EOR
/EOI
```

Figure 4-19. GESS Execution Job Stream for CDC KRONOS/OS

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5.0 OUTPUT INTERPRETATION

5.1 Report Descriptions

The GESS program can, at the user's option, generate up to 31 different output reports. Each of these reports, listed in Table 5.1, describes a different aspect of ejection seat escape simulated performance. The reports show specific performance variables in relation to the simulated time of occurance, and also show the times at which specific sequential events occur. An example series of output reports is presented in Appendix B.

Table 5-1. GESS Report Titles

Report Number	Report Title
1	Input Validation
2	Seat/Occupant Linear Time History
3	Seat/Occupant Angular Time History
4	Occupant Alone Linear Time History
5	Seat Alone Linear Time History
6	Seat Alone Angular Time History
7	Seat/Occupant Linear Time History WRT Aircraft
8	Seat/Occupant Angular Time History WRT Aircraft
9	Occupant Alone Linear Time History WRT Aircraft
10	Seat Alone Linear Time History WRT Aircraft
11	Seat Alone Angular Time History WRT Aircraft
12	Catapult Forces and Moments
13	Rocket 1 Forces and Moments
14	Rocket 2 Forces and Moments

(continued)

Table 5-1. GESS Report Titles (Cont'd)

Report Number	Report Title
15	Rocket 3 Forces and Moments
16	Rocket 4 Forces and Moments
17	Rocket 5 Forces and Moments
18	Rocket 6 Forces and Moments
19	DART Forces and Moments
20	Drogue Forces and Moments
21	Recovery Chute Forces and Moments
22	Thrust Vector Control Microprocessor Data
23	Rail Forces And Moments
24	Seat/Occupant Aerodynamic Forces and Moments
25	Occupant Alone Aerodynamic Forces and Moments
26	Seat Alone Aerodynamic Forces and Moments
27	Occupant Alone Angular Time History (not currently implemented)
28	Aircraft Linear Time History
29	Aircraft Angular Time History
30	Aerodynamic Coefficients Time History
31	Dynamic Center of Gravity Data

5.2 Plotting Files

The user has the option of creating up to two sequential files of simulated trajectory data which can be used for generating trajectory plots on a Calcomp-type plotter. When the IPLOT flag is set equal to 1 (see Section 4.3.1), an EFCS-based plotting file is generated as TAPE42, and an ACS-based plotting file is generated as TAPE41 (see Section 4.4). The contents of either of these files is described in Figure 5-1. The trajectory variables that are recorded in each of these files are listed in Table 5-2.

The plotting files have been specifically designed to be compatible with the Data Reduction and Analysis System (DRAS). This program has three primary capabilities. First, data reduction routines are provided, such as frequency filtering, moving average calculation, interpolation, integration, differentiation, and others. Second, a simplified plot-generation instruction set are provided. Third, output data files may be provided for generating input files for additional analysis.

An example of a DRAS-generated plot, comparing a GESS-calculated trajectory with the trajectory of an ejection seat during field performance testing, is shown in Figure 5-2. The use of the DRAS program in conjunction with GESS plotting files is detailed in Reference 15. Users desiring to access GESS-generated plotting files with other analysis routines should review subroutines PLOTBIN and PLOTWAC, as given in the Volume II GESS Programmer's Manual.

Record No.	File Section
1	Header
1	General Data
2,3	Variable Names
4	Simulation Data
5-n*	Trajectory Data

* one record per time point

Figure 5-1. Plotting File Structure

Table 5-2. TAPE42 Plotting File Trajectory Variables

- TAPE42 Trajectory Variables are in the EFCS.
- TAPE41 Trajectory Variables are in the ACS.

Variable No.	Variable Name
1	time
2	SO/OA x-acceleration
3	SO/OA y-acceleration
4	SO/OA z-acceleration
5	SO/OA total acceleration
6	SO/OA x-velocity
7	SO/OA y-velocity
8	SO/OA z-velocity
9	SO/OA total velocity
10	SO/OA x-position
11	SO/OA y-position
12	SO/OA z-position
13	SO/OA roll rate
14	SO/OA pitch rate
15	SO/OA yaw rate
16	SO/OA roll angle
17	SO/OA pitch angle
18	SO/OA yaw angle
19	SO/SA x-acceleration
20	SO/SA y-acceleration
21	SO/SA z-acceleration
22	SO/SA total acceleration
23	SO/SA x-velocity
24	SO/SA y-velocity
25	SO/SA z-velocity
26	SO/SA total velocity
27	SO/SA x-position
28	SO/SA y-position
29	SO/SA z-position
30	SO/SA roll rate
31	SO/SA pitch rate
32	SO/SA yaw rate
33	SO/SA roll angle
34	SO/SA pitch angle
35	SO/SA yaw angle

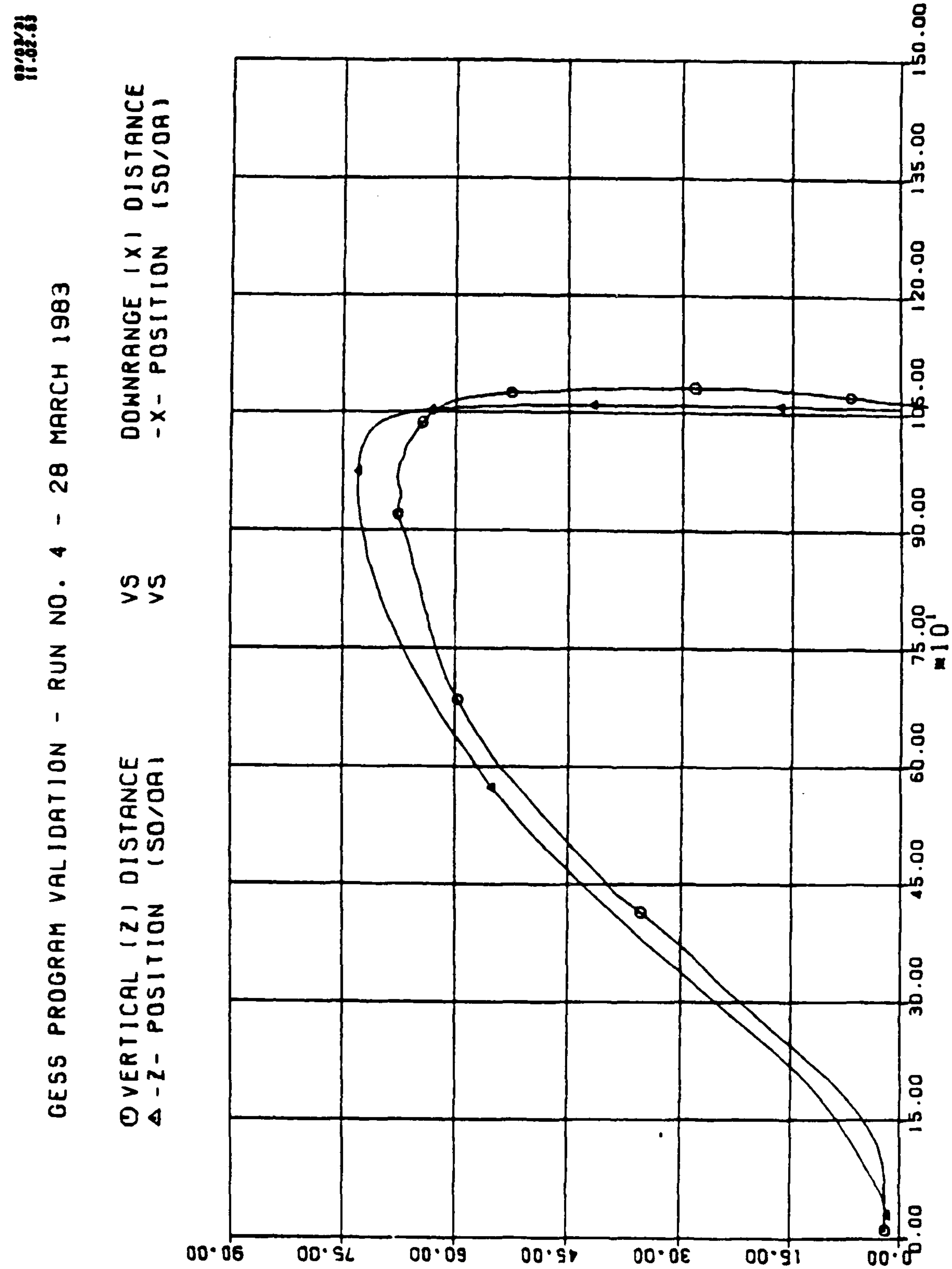

Figure 5-2. Sample DRAS-Generated Trajectory Plots

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6.0 PERFORMANCE ASSESSMENT

A series of simulations has been performed using input variables extracted from ejection sled test data obtained at the Naval Weapons Center Supersonic Naval Ordinance Research Track (NWC/SNORT) facility at China Lake, CA during the ESCAPAC Replacement Test Program. A summary of the input variables describing these simulations are listed in Table 6-1 while the complete input listings of these simulations are presented in Appendix D. The sled tests chosen for these simulations were selected based upon dummy size (3 and 98 percentile) and sled downrange velocity (zero, low, and high speeds).

To enhance the interpretation of the simulation and test data comparisons, a series of plots was generated, comparing each of the simulation trajectories to the photometric trajectory data taken from the corresponding sled test. Four types of comparison plots were generated for each of four simulation/test data sets, and the four plots of each type are presented in Figures 6-1 through 6-4. These figures are discussed in detail below.

Figure 6-1 illustrates the seat/occupant (S/O) and occupant alone (O/A) trajectories in the X-Z plane. It can be seen that, despite the wide variations in wind, aircraft velocity, and dummy weight, the simulated trajectories closely parallel their corresponding test (actual) trajectories. It should be noted that three of the four simulations exhibited higher trajectory apogee than test apogee. In simulation 2, predicted apogee is approximately 50 percent higher than actual. However, the downrange distance at impact, in all cases, shows excellent agreement.

Figure 6-2 illustrates the downrange velocity time histories of the S/O-O/A. Despite a wide variation in the initial ejection velocities, and

Table 6-1. Test Data Used as Simulation Input

Simulation Number	1	2	3	4
ER A-7 Test System	SRT	DVT	DVT	DVT
Test Number	P1	3	2	1
Test Date*	5/20	4/19	3/27	3/13
Dummy Percentile (%)	98	3	98	3
Dummy Weight (lbs)	250.7	174.2	255.5	169
Total Ejected Weight (lbs)	414.2	341.2	418.5	333
S/O CG Location, X Axis (in)	10.7	8.58	10.22	8.57
S/O CG Location, Z Axis (in)	12.3	11.62	12.43	11.47
X Velocity at Ejection (KEAS)	0	442	201	0
Air Density (slug/ft^3 x 10^{-5})	212	211	216	219
Wind Vector (deg wrt traj. vector)	220	230	30	10
Wind Velocity (ft/sec)	6.7	7.0	21.9	23.6
Air Temperature (deg F)	71.5	75	59	56
Barometric Pressure (in H_g)	27.4	27.4	27.3	27.5
Time of Seat First Motion (sec)	0.031	0.020	0.026	0.018
Time of Drogue Projection (sec)	0.166	0.155	0.158	0.148
Time of Drogue Inflation (sec)	1.700	0.286	0.394	0.629
Time of Booster Rocket Ignition (sec)	0.187	0.179	0.188	0.180
Time of Booster Rocket Burnout (sec)	0.423	0.415	0.436	0.427
Time of Parachute Deployment (sec)	0.289	1.417	0.333	1.585
Time of Parachute Line Stretch (sec)	0.697	1.685	0.581	2.098
Time of Seat/Occupant Separation (sec)	0.968	1.920	0.768	2.484
Time of Parachute Full Inflation (sec)	3.520	2.668	1.572	3.760

* All tests conducted during 1981.

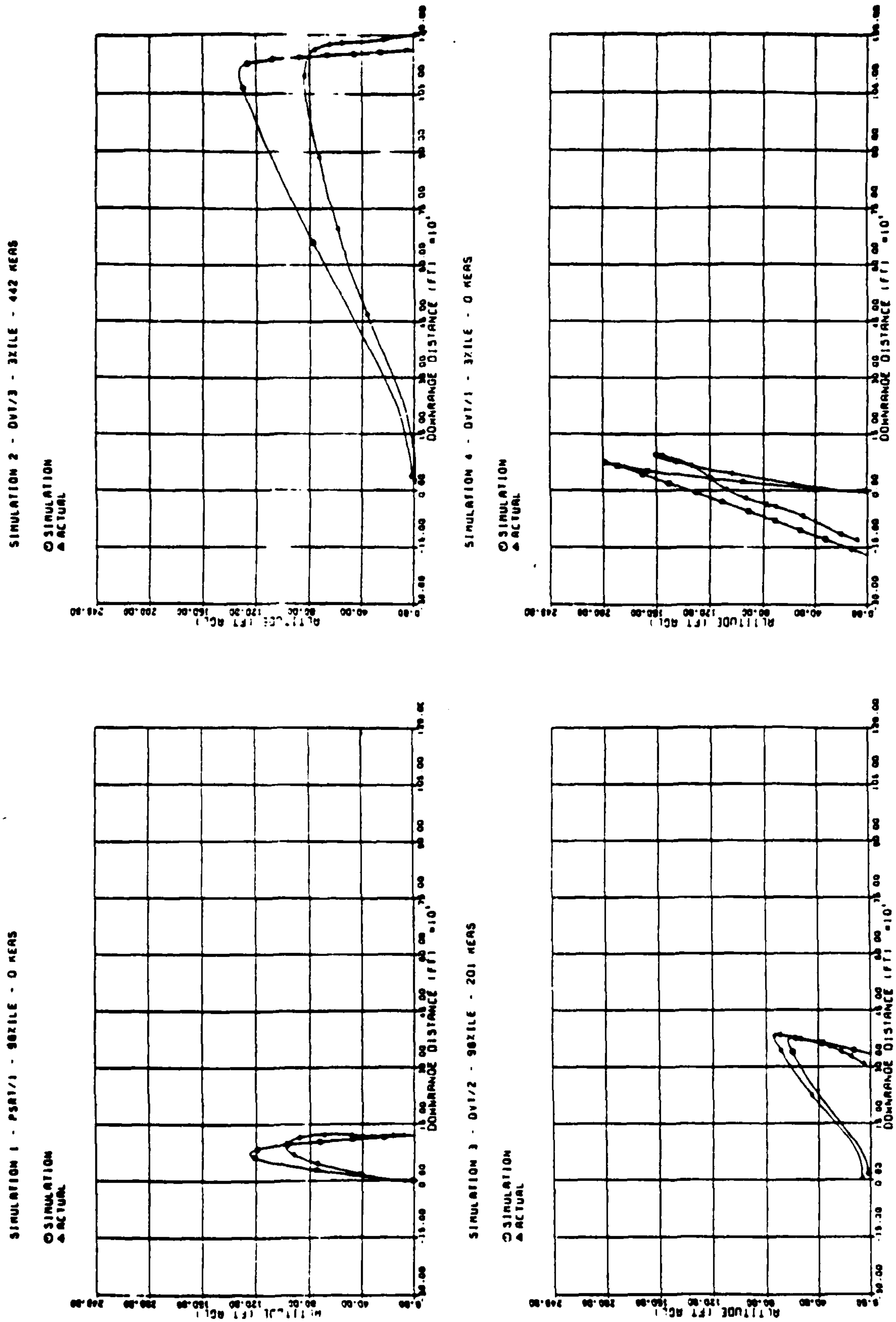

FIGURE 6-1. Seat/Occupant - Occupant Alone Altitude (Z-Axis) vs Downrange (X-Axis) Distance

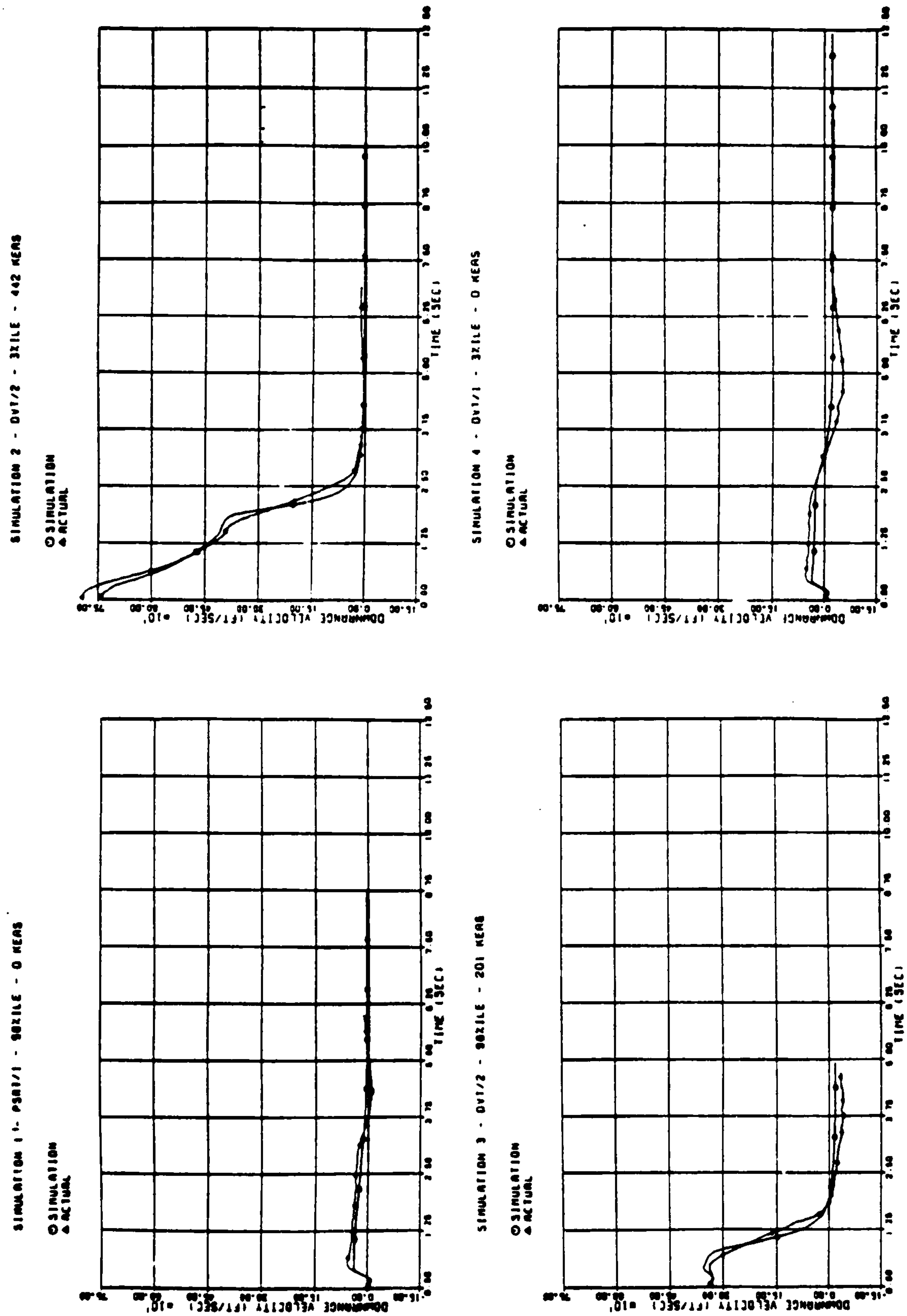

FIGURE 6-2. Seat/Occupant - Occupant Alone Downrange (X-Axis) Velocity vs Time

the distinctive changes in the deceleration rates, the simulation curves show exceptionally close comparisons with the actual data.

Figure 6-3 illustrates the vertical velocity time histories of the S/O-O/A. Here, all plots show an extended vertical acceleration for the simulated curve relative to the actual curve. This could possibly be due to a shorter actual rocket thrust period or a stronger than anticipated DART braking force. The extended acceleration could easily explain the higher predicted trajectory apogee tendency noted in Figure 6-1.

Finally, Figure 6-4 illustrates the total velocity time history of the S/O-O/A. It can be seen that in all cases the agreement between the simulated and actual time histories is again excellent.

Since "the purpose of all computation is insight, rather than numbers"[10], it is essential that the user know and understand the effective limits to the use of the GESS program. The foregoing brief analysis, while not intended as a complete validation study, suggests that the GESS program provides good representation of actual escape system performance. The model has not been designed to duplicate the intrinsic stochastic variability that exists in real world ejection situations, and should not be used with that intent. However, we conclude that when correctly used with reasonably accurate input data, the GESS program will provide highly reliable, detailed descriptions of escape system performance.

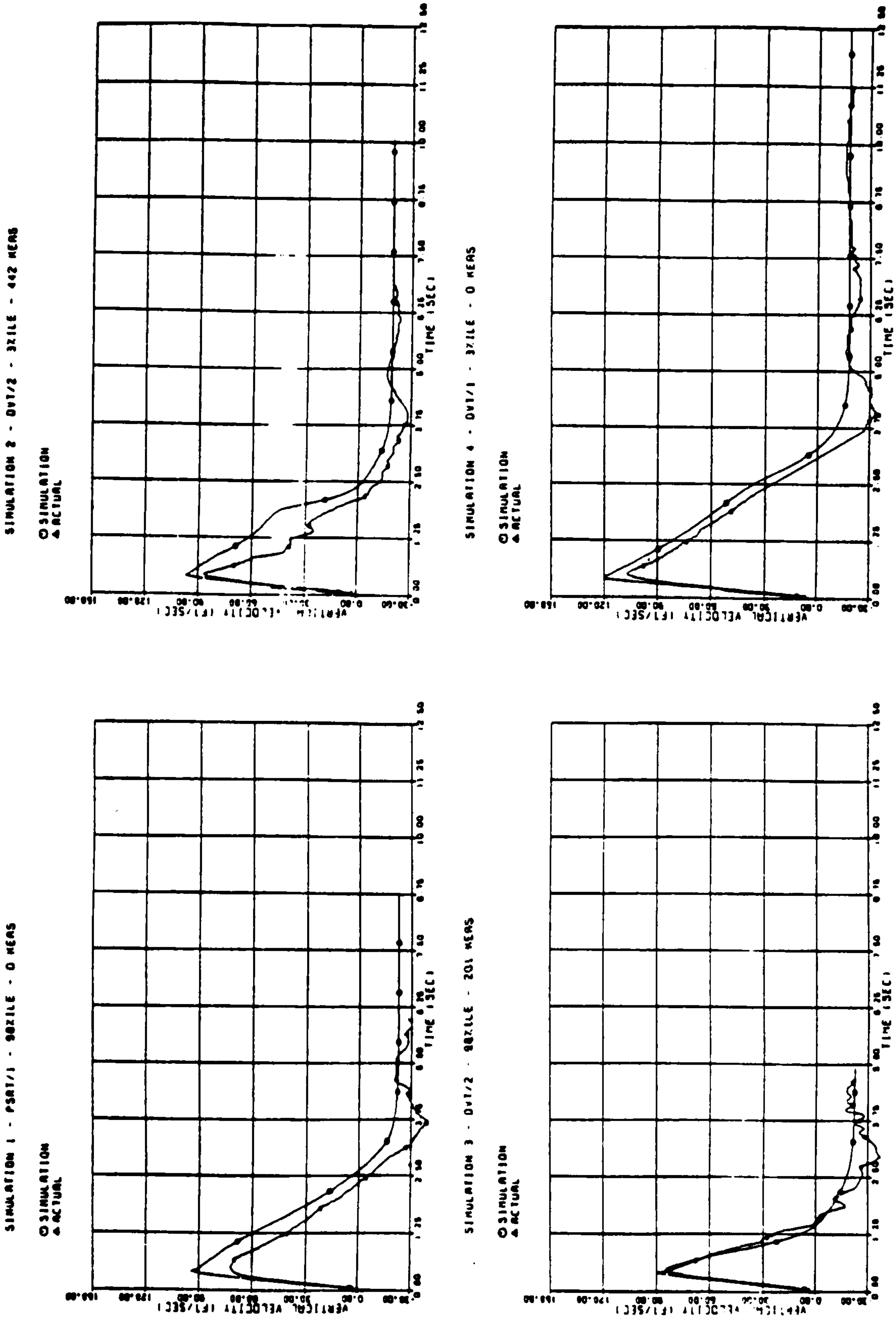

FIGURE 6-3. Seat/Occupant - Occupant Alone Vertical Velocity (Z-Axis) vs Time

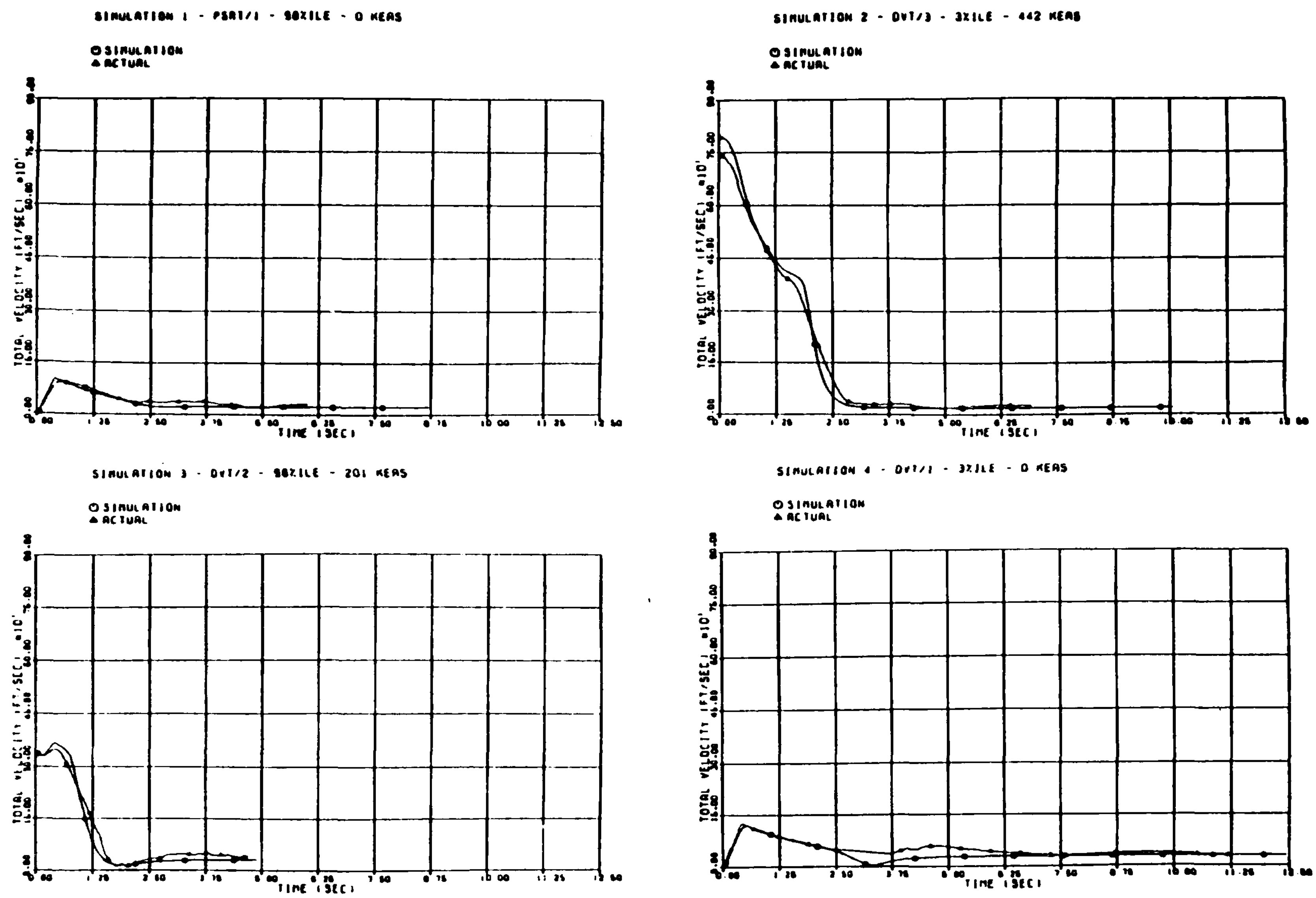

FIGURE 6-4. Seat/Occupant - Occupant Alone Total Velocity vs Time

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7.0 REFERENCES

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APPENDIX A

ACT Program Description

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APPENDIX A

AERODYNAMIC COEFFICIENT TABLES

The Aerodynamic Coefficient Tables (ACT) program creates aerodynamic coefficient tables that are functions of either two or three independent variables. The format in which the ACT tables are created is designed to be similar to the format in which the experimental data are received. A maximum of 500 entries are allowed in a table. For three-way tables, the coefficients are functions of the angle of attack (ALPHA), the angle of sideslip (BETA), and mach number (MACH). The two-way tables may be functions of BETA and MACH, BETA and ALPHA, or ALPHA and MACH.

By specifying the order in which the data must be read into memory, and through the use of variable dimensioned arrays, the user can easily store and reference the tables on random access files. As the coefficients are stored in consecutive locations in memory, it is necessary that the data be read as follows:

- For three-way data:

  C(I,J,K)=F((((ALPHA(I),BETA(J),MACH(K)),I=1,L),J=1,M),K=1,N)

- For two-way data:

  C(J,K)=F(((BETA(J),MACH(K)),J=1,M),K=1,N)

  or C(J,I)=F(((BETA(J),ALPHA(I)),J=1,M),I=1,L)

  or C(I,K)=F(((ALPHA(I),MACH(K)),I=1,L),K=1,N)

L, M, and N are the number of ALPHA, BETA, and MACH coordinates, respectively. Proper dimensioning of the coefficient array facilitates printout of the tables.

A.1 SEQUENCE NUMBERS

A sequence number is assigned to each table and is used to reference the disk address at which the table is stored. During creation runs the program assigns consecutive numbers to the tables as they are read. Three-way tables are assigned sequence numbers 1 to 20, and two-way tables are assigned sequence numbers 21 to 50. See Reference 13 for further information on random files and sequence numbers.

When the tables are extended, the program searches the appropriate info array (see Section A.3.2) to determine the sequence number of the last random file table. Each table that is added is assigned the next available sequence number. During this search, a check is made to ensure that the tables will not be extended beyond their limit. To replace a table, the user must specify the sequence number of the table he wishes to replace.

A.2 INFO ARRAYS

Associated with each table is an INFO array, containing information about that table. INFO3 is a 20 by 13 array associated with three-way tables, and INFO2 is a 30 by 10 array associated with two-way tables. These arrays are updated and written to a random file after creating, extending, or replacing tables. To facilitate referencing, the 20 by 13 INFO array is assigned disk address 51, and the 30 by 10 INFO array is assigned disk address 52.

During an extension run, the proper INFO array is interrogated to determine the number of tables already on random file. The new tables are assigned the next available sequence numbers, provided there is room to extend them. In the replacement mode, the first word in the INFO array for the given sequence number is checked to be sure that a table with that sequence number already exists.

The contents of the INFO array, with J representing the sequence number of the current table being processed, are as shown below.

For two-way tables:

INFO2(J,1) - table identifier
INFO2(J,2) - number of BETAs
INFO2(J,3) - number of MACHs
INFO2(J,4) - BETA delta*
INFO2(J,5) - MACH delta*
INFO2(J,6) - minimum BETA
INFO2(J,7) - minimum MACH
INFO2(J,8) - maximum BETA
INFO2(J,9) - maximum MACH
INFO2(J,10)- type of two-way table

Depending on the type of two-way table being processed, either BETA or MACH, as used above, may be replaced by ALPHA.

For three-way tables:

INFO3(J,1) - table identifier
INFO3(J,2) - number of ALPHAs
INFO3(J,3) - number of BETAs
INFO3(J,4) - number of MACHs

* delta: increment between variable points

INFO3(J,5) - ALPHA delta*

INFO3(J,6) - BETA delta*

INFO3(J,7) - MACH delta*

INFO3(J,8) - minimum ALPHA

INFO3(J,9) - minimum BETA

INFO3(J,10) - minimum MACH

INFO3(J,11) - maximum ALPHA

INFO3(J,12) - maximum BETA

INFO3(J,13) - maximum MACH

A.3 COMMON VARIABLES

A.3.1 Externally Defined

The following common variables are user-defined through the program input.

ALMAX	BEMIN	DELMAC	ITYPE	MODE	NTYPE
ALMIN	DELALP	FMT	MAMAX	NCOEF	
BEMAX	DELBET	IDENT	MAMIN	NOFTAB	

The mnemonic definitions of the above are presented in Section 4.1.8 of this report.

A.3.2 Internally Defined

Table A-1 gives the definitions for the common variables which are initialized by the program.

* delta: increment between variable points

Table A-1. ACT VARIABLES DEFINITIONS

IBLNK	Hollerith word for blanking out the table name in the INFO array.
IC	The sequence number of the current table. Used in the ACT and INPUTT routines when referencing the INFO array.
IERTEST	Internal test work, set by the ERMSG subroutine, which will alter the flow of the program to compensate for an input error. = 1: ignore present case, read next type 1 card = 2: read excess tables into a dummy name = 3: disregard present table, read next table = 4: end program after present case
IJ, IK	In a list of extend run, they return the number of tables that have been written into the INFO array.
INFO2, INFO3	Two dimensional array which is equivalenced to the three dimensional array INFO3. The array INFO2 (30,10) contains the INFO array for two-way tables. INFO3 (20,13) contains the INFO array for the tables of three-way data. Detailed information concerning the contents of the INFO array may be found in Secion A.2.
ISEQNO	The sequence number of the table to be replaced. (see Section A.7)
ITABNO	Position of table ISEQNO on the INFO array = ISEQNO-20: for two-way tables = ISEQNO : for three-way tables
I2NO I3NO	The number of two-way and three-way tables, respectively. Used as a counter when printing the file dictionary.
MTEST	A control word used in the PTOUT and WRINFO routines. = 0: read the INFO array from random file prior to processing the first table on a replacement or extension run = 1: do not read the INFO array again = 9: the PTOUT routine only prints the file dictionary
NAL NBE NMA	The number of ALPHA, BETA, and MACH numbers, respectively, that are contained in the present table. Computed by the program from the given maximum, minimum, and range values for each variable.

A.4 SYSTEM ROUTINES

Table A-2 lists the routines called by the ACT program which are available on the CDC system's library. A more complete description of these routines can be found in Reference 13.

Table A-2. System Routines Required by ACT

OPENMS	Informs the operating system that the mass storage file will be a random access file.
READMS	Transfers data from mass storage to central memory.
SECOND	Gives accumulated central processor time.
WRITMS	Transfers data from central memory to mass storage.

A.5 I/O REQUIREMENTS

The input/output requirements of the ACT program require that the following buffer areas be reserved.

TAPE10/INPUT	permanent file/ card reader	card images	coded
OUTPUT	printer	program output	coded
TAPE1	local	aerodynamic tables	random, binary

It should be recognized that TAPE1 is a random file which may be saved as a permanent file according to the procedures explained in Reference 12.

A.6 DECK SETUP

The object code for this program is saved as a permanent file. The program may be referenced under the filename ACTBIN. Loading of the program requires 50K octal locations of core memory.

A.6.1 Job Control for Creation Run

The following control cards are required to execute ACT, save the tables that are created, and store these tables on the random file.

- CASE1: (If input data are from cards)

```
JOBNAME,CB50000,T10.

ACCOUNT,NUMBER,PASSWORD.

GET,LGO=ACTBIN.                    binary version of act

LGO.

SAVE,TAPE1=AERO4.                  random aerodynamic co-
                                   efficient file
7/     } multi-punch
  8/
    9

data cards

6/
  7/     }  multi-punch
    8/
      9
```

- CASE2: (If input data are from a permanent file)

```
JOBNAME,CB50000,T10

ACCOUNT,NUMBER,PASSWORD

GET,LGO=ACTBIN

GET,CARDS

LGO,CARDS

SAVE,TAPE1=AERO4

/EOF
```

A.6.2 Job Control for Extension Run

Using the files generated in the creation run, the following control cards are necessary to add or replace tables. This setup can also be used to provide only a listing of the current tables.

- CASE1: (If input data is from cards)

```
JOBNAME,CB50000,T10.
ACCOUNT,NUMBER,PASSWORD.
GET,LGO=ACTBIN.
GET,TAPE1=AERO4.
LGO.
REPLACE,TAPE1=AERO4.
7/
  8/    }    multi-punch
    9
data cards
6/
  7/    }    multi-punch
    8/
      9
```

- CASE2: (If input data is from a permanent file)

```
JOBNAME,CB50000,T10
ACCOUNT,NUMBER,PASSWORD
GET,LGO=ACTBIN
GET,TAPE1=AERO4
GET,CARDS
LGO,CARDS
REPLACE,TAPE1=AERO4
/EOF
```

If the REPLACE card is not included in the above example, any new tables written to TAPE1 will be lost when the program ends. The REPLACE card will not otherwise affect program execution, and may remain in the deck even if no new tables are created.

A.7 CARD INPUT

The following are the five different card types that are recognized by the ACT program. Most runs will only require a subset of these, and, unless specified, they must be in the order shown. All integer data must be right-justified in their appropriate columns,while all alphanumeric data must be left-justified.

- Card type 1

Format	Columns	Mnemonic	Description
I5	1-5	ITYPE	Type of data = 1: Two-way data = 2: Three-way data
I5	6-10	MODE	Type of run = 1: Creation run = 2: Extension run = 3: Replacement run = 4: Short listing = 5: Long listing
I5	11-15	NOFTAB	Number of tables to be processed
I5	16-20	NTYP	Type of two-way table = 1: BETA vs MACH = 2: BETA vs ALPHA = 3: ALPHA vs MACH (Default is NTYP =1)

On a list run (MODE = + or 5), NOFTAB and NTYP do not have to be defined.

- Card type 2

Format	Columns	Mnemonic	Description
8A10	1-80	FMT	The format under which the coefficients will be read

Card types 3, 4, and 5 must be repeated, in sequence, NOFTAB times.

- Card type 3

Format	Columns	Mnemonic	Description
A10	1-10	IDENT	Table name
I5	11-15	NCOEF	Number of coefficients
I5	16-20	ISEQNO	Sequence number of the table to be replaced (when MODE = 3)

- Card type 4

when ITYPE = 2:

Format	Columns	Mnemonic	Description
F8.0	1-8	ALMIN	Minimum ALPHA
F8.0	9-16	ALMAX	Maximum ALPHA
F8.0	17-24	DELALP	ALPHA Range
F8.0	25-32	BEMIN	Minimum BETA
F8.0	33-40	BEMAX	Maximum BETA
F8.0	41-48	DELBET	BETA Range
F8.0	49-56	MAMIN	Minimum MACH
F8.0	57-64	MAMAX	Maximum MACH
F8.0	65-72	DELMAC	MACH Range

when ITYPE = 1:

Format	Columns	Mnemonic	Description		
			NTYP=1	NTYP=2	NTYP=3
F8.0	25-32	BEMIN	Min. BETA	Min. BETA	Min. ALPHA
F8.0	33-40	BEMAX	Max. BETA	Max. BETA	Max. ALPHA
F8.0	41-48	DELBET	BETA Range	BETA Range	ALPHA Range
F8.0	49-56	MAMIN	Min. MACH	Min. ALPHA	Min. MACH
F8.0	57-64	MAMAX	Max. MACH	Max. ALPHA	Max. MACH
F8.0	65-72	DELMAC	MACH Range	ALPHA Range	MACH Range

° Card type 5

Format	Columns	Description
Specified by the user in Card Type 2.		TABLE COEFFICIENTS

See Section A.1 for a further description of how the table coefficients must be inputted.

A.8 EXECUTION ERRORS

Types of errors that may be found include:

1. Number of tables greater than 50
2. Number of coefficients greater than 500
3. Invalid use of replace mode
4. Read excess tables into dummy file
5. Two-way tables fully extended
6. Attempt to extend two-way tables beyond 30
7. Three-way tables fully extended
8. Attempt to extend three-way tables beyond 20
9. Error in number of coefficients defined

The ACT program provides a method of continuing execution of the program, despite the discovery of an input error. The user is informed of the error that has been found, which will enable him to correct it in a later run. In cases where a serious error causes the program to end,the INFO array for all previously created tables is written to the random file.

Under a LIST run (mode = 4 or 5), only card type 1 is recognized. For all other runs, all five card types are required. After each set of input is processed, the next card type 1 is read. The program will terminate upon reading an end of information card.

The program is designed to check for obvious input errors, and make the appropriate adjustments to compensate for them. The subroutine ERMSG handles the printing of the error messages, which indicate the source of the error and the action that will be taken by the program. An attempt is always made to save the INFO array before terminating the program due to an input error.

Figures A-1 and A-2 are provided as examples of the inputs needed to execute the ACT program.

```
  1    1    3    3
(14F5.1)
CXS          95
                             0.       360.      20.     0.      1.2       .3
-1.0 -0.8 -0.4 -0.2  0.0   0.2  0.4  0.8  1.0  0.8  0.7  0.6  0.4  0.0
-0.4 -0.6 -0.8 -0.9 -1.0
-1.0 -0.8 -0.4 -0.2  0.0   0.2  0.4  0.8  1.0  0.8  0.7  0.6  0.4  0.0
-0.4 -0.6 -0.8 -0.9 -1.0
-1.0 -0.8 -0.4 -0.2  0.0   0.2  0.4  0.8  1.0  0.8  0.7  0.6  0.4  0.0
-0.4 -0.6 -0.8 -0.9 -1.0
-1.2 -1.0 -0.6 -0.2  0.2   0.3  0.6  0.9  1.0  0.9  0.7  0.6  0.4  0.0
-0.4 -0.8 -1.0 -1.2 -1.2
-1.3 -1.0 -0.7 -0.2  0.0   0.2  0.5  1.0  1.2  1.0  0.8  0.6  0.4  0.2
-0.4 -0.9 -1.1 -1.2 -1.2
CZS          95
                             0.       360.      20.     0.      1.2       .3
 0.3  0.0 -0.4 -0.5 -0.6  -0.7 -0.8 -0.7 -0.4 -0.2  0.0  0.0  0.3  0.4
 0.5  0.6  0.5  0.4  0.3
 0.3  0.0 -0.4 -0.5 -0.6  -0.7 -0.8 -0.7 -0.4 -0.2  0.0  0.0  0.3  0.4
 0.5  0.6  0.5  0.4  0.3
 0.3  0.0 -0.4 -0.5 -0.6  -0.7 -0.8 -0.7 -0.4 -0.2  0.0  0.0  0.3  0.4
 0.5  0.6  0.5  0.4  0.3
 0.4  0.0 -0.4 -0.6 -0.6  -0.8 -0.7 -0.4  0.0  0.1  0.0  0.1  0.2  0.4
 0.6  0.5  0.6  0.4  0.2
 0.1  0.0 -0.4 -0.7 -0.8  -0.8 -0.9 -0.8 -0.5 -0.2  0.0  0.2  0.4  0.4
 0.6  0.7  0.6  0.5  0.3
 CMS         95
                             0.       360.      20.     0.      1.2       .3
-0.10-0.05 0.00 0.10 0.15  0.15 0.15 0.10 0.19-0.08-0.10-0.10-0.10-0.02
 0.0  0.05 0.0 -0.05-0.10
-0.10-0.05 0.00 0.10 0.15  0.15 0.15 0.10 0.19-0.08-0.10-0.10-0.10-0.02
 0.0  0.05 0.0 -0.05-0.10
-0.10-0.05 0.00 0.10 0.15  0.15 0.15 0.10 0.19-0.08-0.10-0.10-0.10-0.02
 0.0  0.05 0.0 -0.05-0.10
-0.15-0.10 0.0  0.10 0.15  0.17 0.13 0.10 0.05 0.50 0.10 0.15 0.10 0.05
 0.0  0.90 0.0  0.90-0.15
 0.15-0.05 0.0  0.13 0.15  0.19 0.18 0.10 0.05-0.05-0.13-0.18-0.10-0.02
 0.0  0.0  0.02-0.10-0.15
```

Figure A-1. ACT Sample Input-Catalogue Run

```
   1    2    2    1
(14F5.1)
CYS          50
                              0.        45.       5.    0.      1.2      .3
0.0 -0.10 -0.15 -0.30 -0.35 -0.50 -0.60 -0.70 -0.85 -1.00
0.0 -0.10 -0.15 -0.30 -0.35 -0.50 -0.60 -0.70 -0.85 -1.00
0.0 -0.10 -0.15 -0.30 -0.35 -0.50 -0.60 -0.70 -0.85 -1.00
0.0 -0.10 -0.20 -0.40 -0.50 -0.60 -0.80 -0.90 -1.00 -1.20
0.0 -0.10 -0.30 -0.50 -0.60 -0.80 -0.90 -1.10 -1.20 -1.40
CLS          50
                              0.        45.       5.    0.      1.2      .3
0.0 +0.01 +0.02 +0.04 +0.05 +0.07 +0.09 +0.09 +0.09 +0.08
0.0 +0.01 +0.02 +0.04 +0.05 +0.07 +0.09 +0.09 +0.09 +0.08
0.0 +0.01 +0.02 +0.04 +0.05 +0.07 +0.09 +0.09 +0.09 +0.08
0.0 +0.01 +0.02 +0.04 +0.05 +0.07 +0.09 +0.09 +0.09 +0.08
0.0 +0.01 +0.02 +0.04 +0.05 +0.07 +0.09 +0.09 +0.09 +0.08
   1    3     1     1
(14F5.1)
CNS          50    23
                              0.        45.       5.    0.      1.2      .3
0.0 -0.01 -0.03 -0.05 -0.07 -0.08 -0.10 -0.12 -0.13 -0.14
0.0 -0.01 -0.03 -0.05 -0.07 -0.08 -0.10 -0.12 -0.13 -0.14
0.0 -0.01 -0.03 -0.05 -0.07 -0.08 -0.10 -0.12 -0.13 -0.14
0.0 -0.01 -0.03 -0.05 -0.06 -0.10 -0.12 -0.13 -0.14 -0.15
0.0 -0.01 -0.03 -0.05 -0.08 -0.10 -0.12 -0.13 -0.14 -0.15
```

Figure A-2. ACT Sample Input - Extension Run

APPENDIX B

Sample GESS Input File Listing

```
START
GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TSTART          0.0 TSTOP           0.0 ESTOP          28 IRESTRT        0
IUNITS            1 ISEATTR           0 ISOSEP          2 IPLOT          0
IDRIFLG           0
IREPTS( 1)        1 IREPTS( 2)        1 IREPTS( 3)      1 IREPTS( 4)     0
IREPTS( 5)        0 IREPTS( 6)        0 IREPTS( 7)      0 IREPTS( 8)     0
IREPTS( 9)        0 IREPTS(10)        0 IREPTS(11)      0 IREPTS(12)     0
IREPTS(13)        0 IREPTS(14)        0 IREPTS(15)      0 IREPTS(16)     0
IREPTS(17)        0 IREPTS(18)        0 IREPTS(19)      0 IREPTS(20)     0
IREPTS(21)        0 IREPTS(22)        0 IREPTS(23)      0 IREPTS(24)     0
IREPTS(25)        0 IREPTS(26)        0 IREPTS(27)      0 IREPTS(28)     0
IREPTS(29)        0 IREPTS(30)        0 IREPTS(31)      0
PI1             100 PI2             100 PI3            20
DTPHAS1       .0001 DTPHAS2        .001 DTPHAS3      .005
TEMP           92.0 PRESSUR       919.1 DENSITY    .00205
XPOS            0.0 YPOS            0.0 ZPOS        0.001
YAW             0.0 PITCH           0.0 ROLL          0.0
RVEL            0.0 QVEL            0.0 PVEL          0.0
WINDX        -2.944 WINDY        -1.700 WINDZ         0.0
XACVEL        600.9 ZACVEL          0.0 CKPITHT       3.5
NPTSAAT           0
NPTSLAT           0
XPOSSRP        .165 YPOSSRP         0.0 ZPOSSRP       .55
XCGSA         .3625 YCGSA           0.0 ZCGSA      1.4000
IXXSA           4.0 IXYSA           0.0 IXZSA         0.0
IYYSA           5.0 IYZSA           0.0 IZZSA         1.0
PHISA           0.0 PSISA         -15.0 THESA         0.0
AREASA          6.0 HGHTSA          3.5 WGHTSA      169.5
XPOSBOT         0.0 YPOSBOT         0.0 ZPOSBOT       0.0
XPOSSCS         0.0 YPOSSCS         0.0 ZPOSSCS       0.0
XCGSO        0.8650 YCGSO           0.0 ZCGSO       .9850
IXXSO          22.0 IXYSO           0.0 IXZSO         0.0
IYYSO          22.0 IYZSO           0.0 IZZSO         6.3
AREASO          7.5 WGHTSO        427.5
AREAOAA         9.6 WGHTOAB       258.0 WGHTOAA     258.0
SOSEP         80.00 DMPGC          0.40
RAILNTH         3.5 RAILANG       -17.5
ISTRL             1 NSLBKS            0
KXSB        50000.0 KYSB         50000. MUSB        0.050
YKTOR         500.0
XPOSRRE         0.0 YPOSRRE      -.4167 ZPOSRRE       0.0
XPOSLRE         0.0 YPOSLRE       .4167 ZPOSLRE       0.0
INCAT             2
CATLNT(1)       3.5 CATSTK(1)       3.5 TCI(1)        0.0
XPOSAP(1)       0.0 YPOSAP(1)    -.4167 ZPOSAP(1)     3.5
NPTSCT(1)         4
                0.0                 0.0              0.01            2450.0
               0.16              2450.0              0.20               0.0
CATLNT(2)       3.5 CATSTK(2)       3.5 TCI(2)        0.0
XPOSAP(2)       0.0 YPOSAP(2)     .4167 ZPOSAP(2)     3.5
NPTSCT(2)         4
                0.0                 0.0              0.01            2450.0
               0.16              2450.0              0.20               0.0
ITUBEND           0
INRKT             2
RKIGN(1)        0.0 RKWGHT(1)       6.0 RKBURN(1)   0.225 RKDLY(1)    0.191
XPOSRK(1)       0.0 YPOSRK(1)   -0.5833 ZPOSRK(1) -0.0533
RKALPH(1)     53.15 RKBETA(1)      68.0 RKGAMA(1)    45.0
RKNPTS(1)         7
                0.0                 0.0              0.02            2000.0
```

```
                 0.03              2200.0               0.25             2400.0
                 0.27               300.0               0.29               10.0
                 0.31                 0.0
RKIGN(2)          0.0 RKWGHT(2)       6.0 RKBURN(2)    0.225 RKDLY(2)     0.191
XPOSRK(2)         0.0 YPOSRK(2)    0.5833 ZPOSRK(2)  -0.0533
RKALPH(2)       53.15 RKBETA(2)     112.0 RKGAMA(2)     45.0
RKNPTS(2)           7
                  0.0                 0.0               0.02             2000.0
                 0.03              2200.0               0.25             2400.0
                 0.27               300.0               0.29               10.0
                 0.31                 0.0
IDROGUE             1
TDDPLOY         0.163 DISPLOY        0.00 DROGLL       14.00
DRDRAG1          0.60 DROGPD1        3.25 PDROSD1       0.05
AREADC           0.50 WGHTDC         3.00 CDCC          1.00
XDROGAP          0.00 YDROGAP        0.00 ZDROGAP       2.00
IDROGLS             1
NPTSDLS             2
                 0.00               0.050            1500.00              0.050
IFTDRO1             1
NPTDFT1             2
                 0.00               0.110            1500.00              0.110
IRECOV              1
RECOVLL          25.5 RECDRAG        0.75
RECOVPD         28.00 POROSR         0.05
XRECAP         0.2917 YRECAP         0.00 ZRECAP       3.083
CHALT1        7000.00 CHALT2     14000.00 GLIMIT        0.00
TDELAY           .000
NPTSRDT             1
TRDPLOY         1.491
NPTSRLS             2
                 0.00               0.271              1500.              0.271
IFTRECV             1
NPTSRFT             2
                 0.00               0.896              1500.              0.896
IDART               1
DRTFRCE         900.0 DRTSTRT         8.0 DRTSTOP       21.0
 XDRTAP(1)     0.0417 YDRTAP(1)   -0.4167 ZDRTAP(1)   -0.1917
 XDRTCP(1)     0.6667 YDRTCP(1)   -0.4167 ZDRTCP(1)   -1.6900
 XDRTAP(2)     0.0417 YDRTAP(2)    0.4167 ZDRTCP(2)   -0.1916
 XDRTCP(2)     0.6667 YDRTCP(2)    0.4167 ZDRTCP(2)   -1.6900
ITVC                0
IDYNCG              1
STOP
```

APPENDIX C

Sample GESS Output Reports

```
           DATE: 1 SEP 83                                                                                         PAGE   1
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE:        .00 FT            X VELOCITY:     600.90 FT/SEC      Z VELOCITY:       0.00 FT/SEC
                      YAW:       0.00 DEG                PITCH:       0.00 DEG                ROLL:       0.00 DEG
    TOTAL EJECTED WEIGHT:      427.50 LB
  COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
   REPORT NO.  1: INPUT VALIDATION
```

PROGRAM CONTROL VARIABLES

EJECTION SIMULATION START TIME =   0.0000(IF > 0 FROM RESTART FILE)

EJECTION SIMULATION STOP EVENT =   SEAT/OCCUPANT SEPARATION

VARIABLE	VALUE	DEFINITION
IRESTRT	0	RESTART FILE CREATION SWITCH (0 = NOT CREATED, 1 = CREATED)
IUNITS	1	UNITS OF MEASURMENT (0 = METRIC, 1 = ENGLISH)
ISEATTR	0	SEAT ALONE TRAJECTORY SWITCH (0 = TRAJ. NOT GENERATED, 1 = TRAJ. GENERATED)
IPLOT	0	PLOTTING FILE SWITCH (0 = NOT CREATED, 1 = CREATED WRT EFCS, 2 = CREATED WRT EFCS AND ACS)
ISOSEP	2	SEAT/OCCUPANT SEP. SWITCH (0 = WILL NOT OCCUR, 1 = WILL OCCUR BASED ON TIME 2 = WILL OCCUR BASED ON FORCE)
IDRIFLG	0	DYNAMIC RESPONSE INDEX SWITCH (0= NOT COMPUTED 1= COMPUTED)

```
          DATE: 1 SEP 83                                                                              PAGE   2
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:         .00 FT           X VELOCITY:     600.90 FT/SEC      Z VELOCITY:        0.00 FT/SEC
                       YAW:       0.00 DEG               PITCH:        0.00 DEG               ROLL:        0.00 DEG
     TOTAL EJECTED WEIGHT:      427.50 LB
    COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
     REPORT NO.   1: INPUT VALIDATION


                         OUTPUT REPORTS:  THE FOLLOWING REPORTS WILL BE CREATED

                         REPORT NO.        TITLE
                         ----------        -----

                             1          INPUT VALIDATION
                             2          SEAT/OCCUPANT LINEAR TIME HISTORY
                             3          SEAT/OCCUPANT ANGULAR TIME HISTORY
```

```
                DATE: 1 SEP 83
     RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                      SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
    SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
     TEST CONDITIONS: ALTITUDE:        .00 FT        X VELOCITY:    600.90 FT/SEC     Z VELOCITY:     0.00 FT/SEC
                           YAW:       0.00 DEG            PITCH:      0.00 DEG              ROLL:     0.00 DEG
        TOTAL EJECTED WEIGHT:     427.50 LB
      COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
       REPORT NO.  1: INPUT VALIDATION
```

INTEGRATION TIME STEPS AND PRINT FREQUENCIES

	INTEGRATION STEP (SEC)		PRINT FREQUENCY	
PHASE 1 (INITIATION TO RAIL CLEARANCE)	DTPHAS1 =	.00010	PI1 =	100
PHASE 2 (RAIL CLEARANCE TO SEAT/OCCUPANT SEPARATION)	DTPHAS2 =	.00100	PI2 =	100
PHASE 3 (SEAT/OCCUPANT SEPARATION TO COMPLETION)	DTPHAS3 =	.00500	PI3 =	20

```
            DATE: 1 SEP 83                                                                          PAGE   4
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:         .00 FT         X VELOCITY:      600.90 FT/SEC      Z VELOCITY:       0.00 FT/SEC
                       YAW:        0.00 DEG             PITCH:        0.00 DEG              ROLL:        0.00 DEG
    TOTAL EJECTED WEIGHT:      427.50 LB
     COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
      REPORT NO.  1: INPUT VALIDATION
```

AIRCRAFT INITIAL CONDITIONS

ATMOSPHERIC CONDITIONS

```
TEMPERATURE       (TEMP):     92.0000 DEG FARENHEIT
BAROM PRESSURE (PRESSUR):    918.1000 MILLIBAR
AIR DENSITY    (DENSITY):       .0021 LB  /FT**3
COCKPIT HEIGHT (CKPITHT):      3.5000 FT
WIND VELOCITY     (WINDX):    -2.9440 FT/SEC
                  (WINDY):    -1.7000 FT/SEC
                  (WINDZ):     0.0000 FT/SEC
```

POSITION (EFCS) (FT)		ORIENTATION (EFCS) (DEG)		LINEAR VELOCITY (EFCS) (FT/SEC)		ANGULAR VELOCITY (ACS) (DEG/SEC)	
XPOS:	0.0000	YAW:	0.0000	XACVEL :	600.9000	YAW (RVEL):	0.0000
YPOS:	0.0000	PITCH:	0.0000	YACVEL :	0.0000	PITCH (QVEL):	0.0000
ZPOS:	.0010	ROLL:	0.0000	ZACVEL :	0.0000	ROLL (PVEL):	0.0000

```
          DATE: 1 SEP 83                                                                          PAGE   5
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:        .00 FT          X VELOCITY:     600.90 FT/SEC      Z VELOCITY:       0.00 FT/SEC
                       YAW:       0.00 DEG              PITCH:       0.00 DEG               ROLL:       0.00 DEG
     TOTAL EJECTED WEIGHT:      427.50 LB
   COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
    REPORT NO.   1: INPUT VALIDATION


                                            SEAT ALONE INITIAL CONDITIONS


                                     REFERENCE AREA (AREASA):     6.0000 FT**2
                                            HEIGHT (HGHTSA):     3.5000 FT
                                            WEIGHT (WGHTSA):   169.5000 LB


                      LOCATION OF SEAT BOTTOM (RCS)                         ORIGIN OF SCS (RCS)
                                   (FT)                                           (FT)

                         XPOSBOT:      0.0000                            XPOSSCS:      0.0000
                         YPOSBOT:      0.0000                            YPOSSCS:      0.0000
                         ZPOSBOT:      0.0000                            ZPOSSCS:      0.0000


   LOCATION OF SEAT REFERENCE POINT (SCS)         ORIENTATION (ACS)                 LOCATION OF SEAT ALONE CG (SCS)
                  (FT)                                  (DEG)                                     (FT)

          XPOSSRP:       .1650             ROLL  (PHISA):     0.0000                    XCGSA:       .3625
          YPOSSRP:      0.0000             PITCH (PSISA):   -15.0000                    YCGSA:      0.0000
          ZPOSSRP:       .5500             YAW   (THESA):     0.0000                    ZCGSA:      1.4000


                                               MOMENTS OF INERTIA
                                                  (SLUG-FT**2)

                                             IXXSA:      4.0000
                                             IXYSA:      0.0000
                                             IXZSA:      0.0000
                                             IYYSA:      5.0000
                                             IYZSA:      0.0000
                                             IZZSA:      1.0000
```

```
               DATE: 1 SEP 83                                                                                   PAGE    6
    RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                     SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
   SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
    TEST CONDITIONS: ALTITUDE:          .00 FT          X VELOCITY:      600.90 FT/SEC      Z VELOCITY:        0.00 FT/SEC
                          YAW:         0.00 DEG              PITCH:        0.00 DEG               ROLL:        0.00 DEG
        TOTAL EJECTED WEIGHT:      427.50 LB
      COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
       REPORT NO.   1: INPUT VALIDATION


                                    SEAT/OCCUPANT, OCCUPANT ALONE INITIAL CONDITIONS


                                SEAT/OCCUPANT REFERENCE AREA (AREASO):      7.5000 FT**2
                           OCCUPANT ALONE EFFECTIVE DRAG AREA (AREAOA):     9.6000 FT**2
                                       SEAT/OCCUPANT WEIGHT (WGHTSO):     427.5000 LB
              OCCUPANT ALONE WEIGHT BEFORE SEAT/OCC SEPARATION(WGHTOAB):  258.0000 LB
              OCCUPANT ALONE WEIGHT AFTER  SEAT/OCC SEPARATION(WGHTOAA):  258.0000 LB
                            SEAT/OCCUPANT SEPARATION OCCURS AT (SOSEP):    80.0000 LB PARACHUTE FORCE
                              AERODYNAMIC DAMPING COEFFICIENT (DMPGC):       .4000


                                    LOCATION OF SEAT/OCCUPANT C.G. (SCS)
                                                  (FT)

                                        XCGSO:      .8650
                                        YCGSO:     0.0000
                                        ZCGSO:      .9850

                                    SEAT/OCCUPANT MOMENTS OF INERTIA
                                              (SLUG-FT**2)

                                        IXXSO:    22.0000
                                        IXYSO:     0.0000
                                        IXZSO:     0.0000
                                        IYYSO:    22.0000
                                        IYZSO:     0.0000
                                        IZZSO:     6.3000
```

```
           DATE: 1 SEP 83                                                                                  PAGE    7
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE:        .00 FT         X VELOCITY:     600.90 FT/SEC      Z VELOCITY:       0.00 FT/SEC
                      YAW:       0.00 DEG             PITCH:       0.00 DEG              ROLL:        0.00 DEG
     TOTAL EJECTED WEIGHT:     427.50 LB
    COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
     REPORT NO.   1: INPUT VALIDATION


                                       RAIL INITIAL CONDITIONS


                               RAIL LENGTH (RAILNTH:        3.5000 FT
                    RAIL ANGLE WRT AIRCRAFT(RAILANG):      -17.5000 DEG
                  X-DIRECTION SPRING CONSTANT(KXSB):   50000.0000 LB/FT
                  Y-DIRECTION SPRING CONSTANT(KYSB):   50000.0000 LB/FT
                       COEFFICIENT OF FRICTION(MUSB):         .0500
                   TORSIONAL SPRING CONSTANT(YKTOR):     500.0000 FT-LB/DEG

                             LOCATION OF RAIL ATTACHMENT POINTS (ACS)
                                            (FT)

              RIGHT                                                  LEFT

          XPOSRRE:       0.0000                          XPOSLRE:      0.0000
          YPOSRRE:       -.4167                          YPOSLRE:       .4167
          ZPOSRRE:       0.0000                          ZPOSLRE:      0.0000

                               NUMBER OF SLIPPERS ON SEAT:    0


                           (PROGRAM ASSUMES A CONTINUOUS "RAIL WITHIN A RAIL")
```

```
        DATE: 1 SEP 83                                                                                    PAGE   8
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:          .00 FT          X VELOCITY:      600.90 FT/SEC      Z VELOCITY:        0.00 FT/SEC
                       YAW:        0.00 DEG               PITCH:        0.00 DEG               ROLL:        0.00 DEG
    TOTAL EJECTED WEIGHT:        427.50 LB
  COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
   REPORT NO.   1: INPUT VALIDATION


                                         CATAPULT PARAMETERS


  NUMBER OF CATAPULTS:   2
                                                                                   LOCATION OF CATAPULT
                                                                                 ATTACHMENT POINTS (SCS)
                                                                                          (FT)

     CATAPULT 1:          LENGHT (CATLNT):           3.5000 FT                   XPOSAP:   0.0000
                          STROKE (CATSTK):           3.5000 FT                   YPOSAP:   -.4167
                          TIME OF IGNITION (TCI):    0.0000 SEC                  ZPOSAP:   3.5000

     CATAPULT 2:          LENGHT (CATLNT):           3.5000 FT                   XPOSAP:   0.0000
                          STROKE (CATSTK):           3.5000 FT                   YPOSAP:    .4167
                          TIME OF IGNITION (TCI):    0.0000 SEC                  ZPOSAP:   3.5000
```

```
            DATE: 1 SEP 83
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:       .00 FT         X VELOCITY:    600.90 FT/SEC     Z VELOCITY:      0.00 FT/SEC
                       YAW:      0.00 DEG             PITCH:      0.00 DEG              ROLL:      0.00 DEG
     TOTAL EJECTED WEIGHT:     427.50 LB
   COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
    REPORT NO.  1: INPUT VALIDATION
```

CATAPULT 1 THRUST TABLE

TIME (SEC)	THRUST (LB)
0.0000	0.0000
.0100	2450.0000
.1600	2450.0000
.2000	0.0000

CATAPULT 2 THRUST TABLE

TIME (SEC)	THRUST (LB)
0.0000	0.0000
.0100	2450.0000
.1600	2450.0000
.2000	0.0000

```
          DATE: 1 SEP 83                                                                                    PAGE  10
   RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                    SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
  SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
   TEST CONDITIONS: ALTITUDE:        .00 FT          X VELOCITY:     600.90 FT/SEC     Z VELOCITY:       0.00 FT/SEC
                         YAW:       0.00 DEG              PITCH:       0.00 DEG               ROLL:       0.00 DEG
      TOTAL EJECTED WEIGHT:     427.50 LB
    COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
     REPORT NO.   1: INPUT VALIDATION


                                                    ROCKET PARAMETERS


   NUMBER OF ROCKETS: 2

                                                                                             ROCKET THRUST LINE
                                                          ROCKET NOZZLE LOCATION (SCS)   DIRECTION COSINE ANGLES (SCS)
                                                                   (FT)                           (DEG)

        ROCKET   1:      IGNITION   (RKIGN):     0.0000 FT       XPOSRK :    0.0000         RKALPH :   53.1500
                         FUEL WT    (RKWGHT):    6.0000 LB       YPOSRK :   -.5833          RKBETA :   68.0000
                         BURN TIME  (RKBURN):     .2250 SEC      ZPOSRK :   -.0533          RKGAMA :   45.0000
                         IGN DELAY  (RKDELY):     .1910 SEC

        ROCKET   2:      IGNITION   (RKIGN):     0.0000 FT       XPOSRK :    0.0000         RKALPH :   53.1500
                         FUEL WT    (RKWGHT):    6.0000 LB       YPOSRK :    .5833          RKBETA :  112.0000
                         BURN TIME  (RKBURN):     .2250 SEC      ZPOSRK :   -.0533          RKGAMA :   45.0000
                         IGN DELAY  (RKDELY):     .1910 SEC
```

```
               DATE: 1 SEP 83
    RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                     SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
   SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
    TEST CONDITIONS: ALTITUDE:         .00 FT        X VELOCITY:     600.90 FT/SEC     Z VELOCITY:      0.00 FT/SEC
                          YAW:        0.00 DEG            PITCH:       0.00 DEG             ROLL:      0.00 DEG
      TOTAL EJECTED WEIGHT:      427.50 LB
      COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
       REPORT NO.   1: INPUT VALIDATION
```

ROCKET THRUST TABLES

ROCKET 1

NOMINAL TIME (SEC)	NOMINAL THRUST (LB)	ADJUSTED TIME (SEC)	ADJUSTED THRUST (LB)
0.0000	0.0000	0.0000	0.0000
.0200	2000.0000	.0145	2755.5556
.0300	2200.0000	.0218	3031.1111
.2500	2400.0000	.1815	3306.6667
.2700	300.0000	.1960	413.3333
.2900	10.0000	.2105	13.7778
.3100	0.0000	.2250	0.0000

```
           DATE: 1 SEP 83
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:          .00 FT          X VELOCITY:     600.90 FT/SEC     Z VELOCITY:      0.00 FT/SEC
                       YAW:         0.00 DEG              PITCH:       0.00 DEG              ROLL:      0.00 DEG
    TOTAL EJECTED WEIGHT:        427.50 LB
  COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
   REPORT NO.  1: INPUT VALIDATION
```

ROCKET THRUST TABLES

ROCKET 2

NOMINAL		ADJUSTED	
TIME (SEC)	THRUST (LB)	TIME (SEC)	THRUST (LB)
0.0000	0.0000	0.0000	0.0000
.0200	2000.0000	.0145	2755.5556
.0300	2200.0000	.0218	3031.1111
.2500	2400.0000	.1815	3306.6667
.2700	300.0000	.1960	413.3333
.2900	10.0000	.2105	13.7778
.3100	0.0000	.2250	0.0000

```
             DATE: 1 SEP 83
  RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                   SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
 SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
  TEST CONDITIONS: ALTITUDE:        .00 FT      X VELOCITY:   600.90 FT/SEC    Z VELOCITY:    0.00 FT/SEC
                        YAW:       0.00 DEG          PITCH:     0.00 DEG             ROLL:    0.00 DEG
     TOTAL EJECTED WEIGHT:      427.50 LB
   COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
    REPORT NO.  1: INPUT VALIDATION
```

DART PARAMETERS

```
         DART FORCE (DRTFRCE):   900.0000 LB
DART START DISTANCE (DRTSTRT):     8.0000 FT
 DART STOP DISTANCE (DRTSTOP):    21.0000 FT
```

LEFT DAR: CONFLUENCE POINT (SCS)
(FT)

```
XDRTCPL:      .6667
YDRTCPL:      .4167
ZDRTCPL:    -1.6900
```

RIGHT DART CONFLUENCE POINT (SCS)
(FT)

```
XDRTCPR:      .6667
YDRTCPR:     -.4167
ZDRTCPR:    -1.6900
```

LEFT DART COCKPIT ATTACHMENT POINT (SCS)
(FT)

```
XDRTAPL:      .0417
YDRTAPL:      .4167
ZDRTAPL:     -.1916
```

RIGHT DART COCKPIT ATTACHMENT POINT (SCS)
(FT)

```
XDRTAPR:      .0417
YDRTAPR:     -.4167
ZDRTAPR:     -.1917
```

```
          DATE: 1 SEP 83                                                                                          PAGE  14
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:          .00 FT            X VELOCITY:     600.90 FT/SEC      Z VELOCITY:         0.00 FT/SEC
                       YAW:        0.00 DEG                 PITCH:       0.00 DEG               ROLL:         0.00 DEG
      TOTAL EJECTED WEIGHT:      427.50 LB
    COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
     REPORT NO.   1: INPUT VALIDATION
```

DYNAMIC CG VARIABLES

DEFAULT VALUES USED:

DAMPING CONSTANT (CX):	.3000
DAMPING CONSTANT (CY):	.3000
DAMP;NG CONSTANT (CZ):	.3000
X SPRING MODULUS CONSTANT (SXP):	18000.0000 LB/FT
X SPRING MODULUS CONSTANT (SXN):	18750.0000 LB/FT
Y SPRING MODULUS CONSTANT (SY):	12000.0000 LB/FT
Z SPRING MODULUS CONSTANT (SZN1):	12000.0000 LB/FT
Z SPRING MODULUS CONSTANT (SZN2):	25500.0000 LB/FT
X DIRECTION DEAD ZONE (XSLACK):	.0830 FT
Z DIRECTION DEAD ZONE (ZSLACK):	.0830 FT
Z DIRECTION BOTTOMING ZONE (ZBOT):	-.0830 FT

DATE: 1 SEP 83
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE

TEST CONDITIONS: ALTITUDE:	.00 FT	X VELOCITY:	600.90 FT/SEC	Z VELOCITY:	0.00 FT/SEC
YAW:	0.00 DEG	PITCH:	0.00 DEG	ROLL:	0.00 DEG
TOTAL EJECTED WEIGHT:	427.50 LB				

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
REPORT NO. 1: INPUT VALIDATION

DROGUE CHUTE(S) PARAMETERS

DROGUE TYPE	(IDROGUE = 1) :	STANDARD SINGLE DROGUE
SEAT TRAVEL TO DROGUE CONTAINER/SLUG RELEASE	(DISPLOY) :	0.0000 FT
DROGUE CONTAINER/SLUG RELEASE DELAY	(TDDPLOY) :	.1630 SEC
DROGUE CONTAINER/SLUG REFERENCE AREA	(AREADC) :	.5000 FT
DROGUE CONTAINER/SLUG WEIGHT	(WGHTDC) :	3.0000 LB
DROGUE CONTAINER/SLUG DRAG COEFFICIENT	(CDDC) :	1.0000
DROGUE CHUTE DRAG COEFFICIENT	(DRORAG1) :	.6000
DROGUE CHUTE EFFECTIVE POROSITY	(POROSD1) :	.0500
DROGUE CHUTE LINE LENGTH	(DROGLL) :	14.0000 FT
DROGUE CHUTE PROJECTED DIAMETER	(DROGPD1) :	3.2500 FT

DROGUE CHUTE ATTACHMENT POINT (SCS)
(FT)

XDROGAP:	0.0000
YDROGAP:	0.0000
ZDROGAP:	2.0000

```
           DATE: 1 SEP 83
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                 SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE:        .00 FT     X VELOCITY:    600.90 FT/SEC    Z VELOCITY:     0.00 FT/SEC
                      YAW:       0.00 DEG         PITCH:      0.00 DEG            ROLL:     0.00 DEG
   TOTAL EJECTED WEIGHT:     427.50 LB
  COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
   REPORT NO.   1: INPUT VALIDATION


                                 TABLE OF TIMES FROM
                            DROGUE CONTAINER/SLUG DEPLOYMENT
                              TO DROGUE CHUTE LINE STRETCH
                                       (DROGLS)

VELOCITY AT DROGUE DEPLOYMENT (FT/SEC) :     0.0     1500.0
TIME TO DROGUE LINE STRETCH        (SEC) :   .0500     .0500


                                 TABLE OF TIMES FROM
                               DROGUE CHUTE LINE STRETCH
                                   TO FULL INFLATION
                                       (DROGFT1)

VELOCITY AT DROGUE DEPLOYMENT (FT/SEC) :     0.0     1500.0
TIME TO DROGUE LINE STRETCH        (SEC) :   .1100     .1100
```

```
            DATE: 1 SEP 83
 RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
                  SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
 TEST CONDITIONS: ALTITUDE:        .00 FT          X VELOCITY:    600.90 FT/SEC     Z VELOCITY:      0.00 FT/SEC
                       YAW:       0.00 DEG              PITCH:      0.00 DEG             ROLL:       0.00 DEG
    TOTAL EJECTED WEIGHT:       427.50 LB
  COORDINATE CONVENTIONS:  +X= FORWARD  +Y= LEFT  +Z= UP  +YAW= TURN LEFT  +PITCH= NOSE DOWN  +ROLL= RIGHT WING DOWN
     REPORT NO.  1: INPUT VALIDATION
```

RECOVERY PARACHUTE PARAMETERS

```
TYPE OF CONTROL        (IRECOV = 1): FIXED TIME DELAY
LINE LENGTH              (RECOVLL):      25.5000 FT
DRAG COEFFICIENT         (RECDRAG):        .7500
PROJECTED DIAMETER       (RECOVPD):      28.0000 FT
EFFECTIVE POROSITY        (POROSR):        .0500
LOWER ALTITUDE LIMIT      (CHALT1):    7000.0000 FT
UPPER ALTITUDE LIMIT      (CHALT2):   14000.0000 FT
UPPER ALTITUDE DELAY      (TDELAY):       0.0000 SEC
PARACHUTE RELEASE TIME   (TRDPLOY):       1.4910 SEC
```

RECOVERY CHUTE ATTACHMENT POINT (SCS) (FT)

```
XRECAP:      .2917
YRECAP:     0.0000
ZRECAP:     3.0830
```

TABLE OF TIMES FROM RECOVERY PARACHUTE RELEASE TO LINE STRETCH

VELOCITY (FT/SEC)	TIME (SEC)
0.0	.2710
1500.0	.2710

TABLE OF TIMES FROM RECOVERY PARACHUTE LINE STRETCH TO FULL INFLATION

VELOCITY (FT/SEC)	TIME (SEC)
0.0	.8960
1500.0	.8960

DATE: 1 SEP 83 PAGE 1

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG
TOTAL EJECTED WEIGHT: 427.50 LB
COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
REPORT NO. 2: SEAT/OCCUPANT LINEAR TIME HISTORY

TIME (SEC)	ACCELERATION (SCS) (G[S])				VELOCITY(EFCS) (FT/SEC)				POSITION (EFCS) (FT)			
	X	Y	Z	RES	X	Y	Z	RES	X	Y	Z	RES
0.0000	************************ CATAPULT 1 IGNITION											
0.0000	************************ CATAPULT 2 IGNITION											
0.0000	-.00	.00	0.00	.00	600.90	0.00	-.00	600.90	.58	0.00	1.18	1.31
.0008	************************ SEAT FIRST MOTION											
.0008	-.00	.00	-.05	.05	600.90	.00	-.00	600.90	1.06	.00	1.18	1.58
.0100	-.95	.00	10.35	10.39	600.42	.00	1.46	600.42	6.59	.00	1.18	6.69
.0200	-1.40	.00	10.04	10.14	599.08	.00	4.49	599.10	12.58	.00	1.23	12.64
.0300	2.35	.00	10.23	10.49	598.43	.00	7.68	598.48	18.55	.00	1.32	18.60
.0400	-.06	.00	10.15	10.15	598.17	.00	11.01	598.27	24.53	.00	1.44	24.57
.0500	-2.89	.00	10.03	10.44	596.71	.00	13.98	596.87	30.50	.00	1.59	30.54
.0600	1.09	.00	10.21	10.27	595.52	.00	17.03	595.77	36.45	.00	1.76	36.49
.0700	1.57	.00	10.09	10.21	595.30	.00	20.36	595.65	42.40	.00	1.95	42.44
.0800	-1.85	.00	9.79	9.96	594.42	.00	23.43	594.89	48.35	.00	2.16	48.40
.0900	-.53	.00	9.85	9.87	593.13	.00	26.35	593.71	54.28	.00	2.39	54.34
.1000	1.47	.00	9.94	10.05	592.58	.00	29.51	593.32	60.21	.00	2.66	60.27
.1100	-1.06	.00	9.74	9.80	591.91	.01	32.62	592.81	66.13	.00	2.96	66.20
.1200	-1.56	.00	9.59	9.71	590.58	.01	35.47	591.64	72.04	.00	3.29	72.12
.1300	1.58	.00	9.61	9.74	589.82	.01	38.47	591.07	77.94	.00	3.66	78.02
.1400	.68	.00	9.41	9.44	589.57	.01	41.57	591.03	83.83	.00	4.06	83.93
.1484	************************ CATAPULT 1 SEPARATION											
.1484	************************ CATAPULT 2 SEPARATION											
.1484	************************ RAIL SEPARATION											
.1484	************************ SEAT SEPARATION FROM AIRCRAFT											
.1484	-4.89	.02	-2.09	5.32	588.85	.01	43.97	590.49	88.78	.00	4.42	88.89
.1590	-5.11	.01	-2.13	5.54	587.29	.02	42.87	588.85	95.05	.00	4.88	95.18
.1630	************************ DROGUE GUN/CONTAIN. DEPLOYMENT											
.1630	-5.11	.01	-2.14	5.54	586.71	.02	42.46	588.24	97.40	.00	5.04	97.53
.1910	************************ ROCKET 1 IGNITION											
.1910	************************ ROCKET 2 IGNITION											
.1910	-5.08	.01	-2.22	5.54	582.60	.03	39.62	583.95	113.74	.00	6.11	113.90
.2000	-.29	.01	3.40	3.41	581.81	.03	39.64	583.16	118.98	.00	6.43	119.15
.2130	************************ DROGUE CHUTE LINE STRETCH											
.2130	3.37	.01	7.71	8.41	582.28	.03	42.42	583.82	126.56	.00	6.94	126.75
.2720	************************ DART START RIGHT LINE											
.2720	************************ DART START LEFT LINE											
.2720	2.54	.00	5.63	6.17	585.96	.02	57.65	588.79	161.18	.00	10.08	161.50
.3000	1.17	.00	5.81	5.93	587.13	.01	62.92	590.50	177.58	.00	11.77	177.97
.3230	************************ DROGUE CHUTE FULL INFLATION											
.3230	-.34	-.00	6.34	6.35	586.84	-.00	67.39	590.70	191.04	.00	13.21	191.50
.4000	-8.51	.00	-.44	8.53	577.89	-.08	77.64	583.08	235.88	.00	18.96	236.64
.4160	************************ ROCKET 1 BURNOUT											
.4160	************************ ROCKET 2 BURNOUT											
.4160	-8.19	.00	.44	8.21	574.34	-.10	75.16	579.24	245.10	-.00	20.13	245.93
.4490	************************ DART STOP RIGHT LINE											
.4490	************************ DART STOP LEFT LINE											
.4490	-6.08	.00	3.68	7.11	567.33	-.14	70.73	571.72	263.95	-.00	22.52	264.91

DATE: 1 SEP 83 PAGE 2
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG
TOTAL EJECTED WEIGHT: 427.50 LB
COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
REPORT NO. 2: SEAT/OCCUPANT LINEAR TIME HISTORY

TIME (SEC)	ACCELERATION (SCS) (G(S) X	Y	Z	RES	VELOCITY(EFCS) (FT/SEC) X	Y	Z	RES	POSITION (EFCS) (FT) X	Y	Z	RES
.5000	-4.93	.00	4.65	6.78	556.20	-.15	68.48	560.40	292.60	-.01	26.14	293.76
.6000	-4.07	.00	4.81	6.30	535.44	.02	65.08	539.38	347.15	-.02	32.82	348.69
.7000	-4.21	.00	4.04	5.84	516.20	.24	61.78	519.89	399.71	-.01	39.17	401.63
.8000	-4.71	.00	2.77	5.46	498.50	.31	57.91	501.85	450.44	.02	45.16	452.70
.9000	-4.89	.00	1.85	5.22	482.06	.27	52.93	484.95	499.47	.05	50.69	502.03
1.0000	-4.64	.00	1.59	4.91	466.59	.24	47.68	469.02	546.90	.08	55.72	549.73
1.1000	-4.21	.00	1.71	4.54	452.18	.25	42.89	454.21	592.83	.10	60.25	595.88
1.2000	-3.79	.00	1.88	4.23	438.71	.23	38.72	440.41	637.37	.12	64.33	640.60
1.3000	-3.49	.00	1.90	3.98	426.04	.18	35.04	427.48	680.60	.15	68.01	683.99
1.4000	-3.32	.00	1.77	3.76	414.08	.12	31.60	415.29	722.60	.16	71.35	726.12
1.4910************************ RECOVERY CHUTE DEPLOYMENT												
1.4910	-1.67	.00	.30	1.70	403.78	.08	28.48	404.78	759.81	.17	74.08	763.42
1.5000	-1.67	.00	.29	1.70	403.37	.08	28.22	404.36	763.45	.17	74.33	767.06
1.6000	-1.75	.00	.05	1.75	398.84	.12	25.05	399.63	803.58	.18	76.98	807.26
1.7000	-1.90	.00	-.38	1.94	394.29	.17	21.32	394.86	843.26	.19	79.29	846.98
1.7620************************ RECOVERY CHUTE LINE STRETCH												
1.7620	-2.01	.00	-.75	2.14	391.36	.21	18.49	391.80	867.63	.21	80.49	871.35
1.7920************************ SEAT/OCCUPANT SEPARATION												

DATE: 1 SEP 83 PAGE 1
RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE
SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG
TOTAL EJECTED WEIGHT: 427.50 LB
COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN
REPORT NO. 3: SEAT/OCCUPANT ANGULAR TIME HISTORY

TIME (SEC)	ACCELERATION (SCS) (DEG/SEC 2) X	Y	Z	RES	RATE (EFCS) (DEG/SEC) X	Y	Z	RES	ORIENTATION (EFCS) (DEG) ROLL	PITCH	YAW	RES
0.0000	CATAPULT 1 IGNITION											
0.0000	CATAPULT 2 IGNITION											
0.0000	-.00	-.00	-.00	.00	0.00	0.00	0.00	0.00	0.00	-15.00	0.00	15.00
.0008	SEAT FIRST MOTION											
.0008	-.00	879.88	-.00	879.88	-.00	.35	-.00	.35	-.00	-15.00	.00	15.00
.0100	-.19	6167.97	.03	6167.97	-.00	36.15	.00	36.15	-.00	-14.86	.00	14.86
.0200	-.64	-4550.51	1.03	4550.51	-.00	20.30	.00	20.30	-.00	-14.49	.00	14.49
.0300	-.60	-904.05	3.27	904.05	-.01	-13.32	.02	13.32	-.00	-14.50	.00	14.50
.0400	-.70	-200.91	5.07	200.98	-.01	-7.65	.05	7.65	-.00	-14.61	.00	14.61
.0500	-.52	-142.15	7.72	142.36	-.01	-10.80	.09	10.80	-.00	-14.70	.00	14.70
.0600	-.44	3327.03	10.18	3327.04	-.01	8.64	.13	8.64	-.00	-14.74	.00	14.74
.0700	-.73	357.99	12.23	358.20	-.01	24.44	.18	24.44	-.00	-14.54	.00	14.54
.0800	-.87	-2885.40	14.95	2885.43	-.02	1.21	.23	1.23	-.00	-14.39	.01	14.39
.0900	-.67	-626.90	17.21	627.14	-.02	-15.10	.29	15.11	-.00	-14.49	.01	14.49
.1000	-.59	1263.76	19.52	1263.91	-.02	-5.20	.34	5.21	-.00	-14.60	.01	14.60
.1100	-1.03	1770.72	21.90	1770.85	-.02	8.98	.40	8.99	-.01	-14.58	.02	14.58
.1200	-1.93	2359.28	24.72	2359.41	-.02	23.65	.46	23.65	-.01	-14.42	.02	14.42
.1300	-3.60	1841.78	28.22	1842.00	-.04	33.17	.53	33.17	-.01	-14.13	.03	14.13
.1400	-6.02	3819.56	30.17	3819.69	-.06	42.81	.59	42.81	-.01	-13.76	.03	13.76
.1484	CATAPULT 1 SEPARATION											
.1484	CATAPULT 2 SEPARATION											
.1484	RAIL SEPARATION											
.1484	SEAT SEPARATION FROM AIRCRAFT											
.1484	4.82	-192.76	-4.99	192.88	-.10	72.26	.65	72.27	-.01	-13.29	.04	13.29
.1590	4.51	-196.21	-4.76	196.32	-.05	65.51	.55	65.52	-.01	-12.56	.04	12.56
.1630	DROGUE GUN/CONTAIN. DEPLOYMENT											
.1630	4.49	-173.28	-4.67	173.40	-.03	63.72	.53	63.72	-.01	-12.30	.05	12.30
.1910	ROCKET 1 IGNITION											
.1910	ROCKET 2 IGNITION											
.1910	4.70	135.83	-3.55	135.95	.10	56.08	.36	56.08	-.01	-10.65	.06	10.65
.2000	5.93	697.56	-6.18	697.62	.14	57.91	.30	57.91	-.01	-10.14	.06	10.14
.2130	DROGUE CHUTE LINE STRETCH											
.2130	7.10	786.33	-7.94	786.40	.22	65.53	.19	65.53	-.01	-9.34	.06	9.34
.2720	DART START RIGHT LINE											
.2720	DART START LEFT LINE											
.2720	-1.07	-3294.79	9.98	3294.81	.52	26.91	.16	26.92	.02	-5.85	.06	5.85
.3000	-.99	-4722.12	17.33	4722.15	.44	-82.57	.61	82.57	.03	-6.57	.07	6.57
.3230	DROGUE CHUTE FULL INFLATION											
.3230	-2.00	-5609.13	21.20	5609.17	.37	-189.55	.89	189.56	.03	-9.68	.09	9.68
.4000	-6.41	-510.70	-3.33	510.75	-.18	-320.95	1.19	320.95	-.05	-32.10	.20	32.10
.4160	ROCKET 1 BURNOUT											
.4160	ROCKET 2 BURNOUT											
.4160	-3.88	1202.35	-6.80	1202.37	-.25	-295.56	1.03	295.56	-.09	-37.06	.23	37.06
.4490	DART STOP RIGHT LINE											
.4490	DART STOP LEFT LINE											
.4490	-5.75	473.57	-7.97	473.67	-.21	-190.45	.60	190.46	-.18	-45.25	.32	45.26

DATE: 1 SEP 83 PAGE 2

RUN DESCRIPTION: GESS USERS MANUAL - SAMPLE SIMULATION INPUT/OUTPUT
SIIIS-ER A-7 SRT #4 - 350 KEAS - 98 %OCCUPANT - HIGH SPEED MODE

SEAT DESCRIPTION: STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE

TEST CONDITIONS: ALTITUDE: .00 FT X VELOCITY: 600.90 FT/SEC Z VELOCITY: 0.00 FT/SEC
YAW: 0.00 DEG PITCH: 0.00 DEG ROLL: 0.00 DEG

TOTAL EJECTED WEIGHT: 427.50 LB

COORDINATE CONVENTIONS: +X= FORWARD +Y= LEFT +Z= UP +YAW= TURN LEFT +PITCH= NOSE DOWN +ROLL= RIGHT WING DOWN

REPORT NO. 3: SEAT/OCCUPANT ANGULAR TIME HISTORY

TIME (SEC)	ACCELERATION (SCS) (DEG/SEC 2)				RATE (EFCS) (DEG/SEC)				ORIENTATION (EFCS) (DEG)			
	X	Y	Z	RES	X	Y	Z	RES	ROLL	PITCH	YAW	RES
.5000	-3.04	852.03	-9.34	852.08	-.37	-117.00	.07	117.00	-.31	-53.12	.43	53.12
.6000	.11	1184.57	-.15	1184.57	-.34	2.17	-.38	2.23	-.43	-58.92	.53	58.92
.7000	1.79	764.36	5.77	764.38	-.14	78.41	.07	78.41	-.37	-54.27	.46	54.27
.8000	1.50	35.17	2.68	35.30	.06	85.37	.43	85.37	-.29	-45.40	.40	45.40
.9000	-1.64	-388.55	-2.44	388.56	.03	38.64	.26	38.64	-.25	-39.00	.39	39.01
1.0000	-1.99	-403.34	-2.77	403.35	-.16	-9.28	-.08	9.29	-.25	-37.69	.40	37.69
1.1000	.00	-186.10	.33	186.10	-.18	-30.42	-.15	30.42	-.29	-39.93	.41	39.94
1.2000	.86	37.70	2.20	37.78	-.07	-25.38	.03	25.38	-.33	-42.89	.44	42.90
1.3000	.51	159.83	1.51	159.83	.01	-7.64	.18	7.64	-.37	-44.58	.48	44.59
1.4000	-.10	164.77	-.08	164.77	.02	8.91	.17	8.91	-.38	-44.47	.50	44.47
1.4910************************ RECOVERY CHUTE DEPLOYMENT												
1.4910	.04	603.56	.61	603.56	-.01	16.63	.08	16.63	-.38	-43.24	.50	43.25
1.5000	.04	601.66	.61	601.66	-.01	21.42	.08	21.42	-.37	-43.07	.50	43.08
1.6000	-.16	598.56	.71	598.56	-.01	63.04	.10	63.04	-.33	-38.71	.47	38.71
1.7000	-.56	551.98	.97	551.98	-.04	90.53	.14	90.53	-.26	-30.91	.42	30.91
1.7620************************ RECOVERY CHUTE LINE STRETCH												
1.7620	-.72	476.20	1.23	476.20	-.07	98.61	.17	98.61	-.22	-25.01	.40	25.01
1.7920************************ SEAT/OCCUPANT SEPARATION												

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APPENDIX D

GESS Performance Assessment

Input Listings

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START
GESS PROGRAM VALIDATION - RUN NO. 1 - 28 MARCH 1983
SIIIS-ER A-7 (P)SRT #1 - 0.0 KEAS - 98% OCCUPANT - LOW SPEED MODE
STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TSTART          0.0 TSTOP           0.0 ESTOP            30 IRESTRT          0
IUNITS            1 ISEATTR           0 ISOSEP            1 IPLOT            1
IDRIFLG           1
IREPTS( 1)        1 IREPTS( 2)        1 IREPTS( 3)        0 IREPTS( 4)       1
IREPTS( 5)        0 IREPTS( 6)        0 IREPTS( 7)        0 IREPTS( 8)       0
IREPTS( 9)        0 IREPTS(10)        0 IREPTS(11)        0 IREPTS(12)       0
IREPTS(13)        0 IREPTS(14)        0 IREPTS(15)        0 IREPTS(16)       0
IREPTS(17)        0 IREPTS(18)        0 IREPTS(19)        0 IREPTS(20)       0
IREPTS(21)        0 IREPTS(22)        0 IREPTS(23)        0 IREPTS(24)       0
IREPTS(25)        0 IREPTS(26)        0 IREPTS(27)        0 IREPTS(28)       0
IREPTS(29)        0 IREPTS(30)        0 IREPTS(31)        0
PI1             100 PI2             100 PI3              20
DTPHAS1       .0001 DTPHAS2        .001 DTPHAS3        .005
TEMP           71.5 PRESSUR       915.8 DENSITY      .00212
XPOS            0.0 YPOS            0.0 ZPOS          0.001
YAW             0.0 PITCH           0.0 ROLL            0.0
RVEL            0.0 QVEL            0.0 PVEL            0.0
WINDX         5.132 WINDY        -4.307 WINDZ           0.0
XACVEL          0.0 ZACVEL          0.0 CKPITHT         3.5
NPTSAAT           0
NPTSLAT           0
XPOSSRP        .165 YPOSSRP         0.0 ZPOSSRP         .55
XCGSA         .3625 YCGSA           0.0 ZCGSA        1.4000
IXXSA           4.0 IXYSA           0.0 IXZSA           0.0
IYYSA           5.0 IYZSA           0.0 IZZSA           1.0
PHISA           0.0 PSISA         -15.0 THESA           0.0
AREASA          6.0 HGHTSA          3.5 WGHTSA        163.5
XPOSBOT         0.0 YPOSBOT         0.0 ZPOSBOT         0.0
XPOSSCS         0.0 YPOSSCS         0.0 ZPOSSCS         0.0
XCGSO        0.8917 YCGSO           0.0 ZCGSO         1.025
IXXSO          22.0 IXYSO           0.0 IXZSO           0.0
IYYSO          22.0 IYZSO           0.0 IZZSO           6.3
AREASO          7.5 WGHTSO        414.2
AREAOAA         9.6 WGHTOAB       250.7 WGHTOAA       250.7
SOSEP         0.968 DMPGC          0.40
RAILNTH         3.5 RAILANG       -17.5
ISTRL             1 NSLBKS            0
KXSB        50000.0 KYSB         50000. MUSB          0.050
YKTOR         500.0
XPOSRRE         0.0 YPOSRRE      -.4167 ZPOSRRE         0.0
XPOSLRE         0.0 YPOSLRE       .4167 ZPOSLRE         0.0
INCAT             2
CATLNT(1)       3.5 CATSTK(1)       3.5 TCI(1)       0.0302
XPOSAP(1)       0.0 YPOSAP(1)    -.4167 ZPOSAP(1)       3.5
NPTSCT(1)         4
                0.0                 0.0                0.01             2450.0
               0.16              2450.0                0.20                0.0
CATLNT(2)       3.5 CATSTK(2)       3.5 TCI(2)       0.0302
XPOSAP(2)       0.0 YPOSAP(2)     .4167 ZPOSAP(2)       3.5
NPTSCT(2)         4
                0.0                 0.0                0.01             2450.0
               0.16              2450.0                0.20                0.0
ITUBEND           0
INRKT             2
RKIGN(1)        0.0 RKWGHT(1)       6.0 RKBURN(1)     0.236 RKDELY(1)    0.187
XPOSRK(1)       0.0 YPOSRK(1)   -0.5833 ZPOSRK(1)   -0.0533
RKALPH(1)     53.15 RKBETA(1)      68.0 RKGAMA(1)      45.0
RKNPTS(1)         7
                0.0                 0.0                0.02             2020.0
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                0.03             2200.0                 0.25              2400.0
                0.27              300.0                 0.29                10.0
                0.31                0.0
RKIGN(2)         0.0 RKWGHT(2)      6.0 RKBURN(2)      0.236 RKDELY(2)     0.187
XPOSRK(2)        0.0 YPOSRK(2)   0.5833 ZPOSRK(2)    -0.0533
RKALPH(2)     53.150 RKBETA(2)    112.0 RKGAMA(2)       45.0
RKNPTS(2)          7
                 0.0                0.0                 0.02              2000.0
                0.03             2200.0                 0.25              2400.0
                0.27              300.0                 0.29                10.0
                0.31                0.0
IDROGUE            1
TDDPLOY        0.166 DISPLOY       0.00 DROGLL         14.00
DRDRAG1         0.60 DROGPD1       3.25 POROSD1         0.05
AREADC          0.50 WGHTDC        3.00 CDCC            1.00
XDROGAP         0.00 YDROGAP       0.00 ZDROGAP         2.00
IDROGLS            1
NPTSDLS            2
                0.00              0.464              1500.00               0.464
IFTDRO1            1
NPTDFT1            2
                0.00              1.070              1500.00               1.070
IRECOV             1
RECOVLL         25.5 RECDRAG       0.75
RECOVPD        28.00 POROSR        0.05
XRECAP        0.2917 YRECAP        0.00 ZRECAP         3.083
CHALT1       7000.00 CHALT2    14000.00 GLIMIT          0.00
TDELAY          .000
NPTSRDT            1
TRDPLOY        0.289
NPTSRLS            2
                0.00              0.408                1500.               0.408
IFTRECV            1
NPTSRFT            2
                0.00              2.823                1500.               2.823
IDART              1
DRTFRCE        900.0 DRTSTRT        8.0 DRTSTOP         21.0
 XDRTAP(1)    0.0417 YDRTAP(1)  -0.4167 ZDRTAP(1)    -0.1917
 XDRTCP(1)    0.6667 YDRTCP(1)  -0.4167 ZDRTCP(1)    -1.6900
 XDRTAP(2)    0.0417 YDRTAP(2)   0.4167 ZDRTCP(2)    -0.1916
 XDRTCP(2)    0.6667 YDRTCP(2)   0.4167 ZDRTCP(2)    -1.6900
ITVC               0
IDYNCG             1
STOP
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START
GESS PROGRAM VALIDATION - RUN NO. 2 - 28 MARCH 1983
SIIIS-ER A-7 DVT #3 - 440 KEAS - 3% OCCUPANT - HIGH SPEED MODE
STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TSTART          0.0 TSTOP           0.0 ESTOP            30 IRESTRT          0
IUNITS            1 ISEATTR           0 ISOSEP            1 IPLOT            1
IDRIFLG           1
IREPTS( 1)        1 IREPTS( 2)        1 IREPTS( 3)        0 IREPTS( 4)       1
IREPTS( 5)        0 IREPTS( 6)        0 IREPTS( 7)        0 IREPTS( 8)       0
IREPTS( 9)        0 IREPTS(10)        0 IREPTS(11)        0 IREPTS(12)       0
IREPTS(13)        0 IREPTS(14)        0 IREPTS(15)        0 IREPTS(16)       0
IREPTS(17)        0 IREPTS(18)        0 IREPTS(19)        0 IREPTS(20)       0
IREPTS(21)        0 IREPTS(22)        0 IREPTS(23)        0 IREPTS(24)       0
IREPTS(25)        0 IREPTS(26)        0 IREPTS(27)        0 IREPTS(28)       0
IREPTS(29)        0 IREPTS(30)        0 IREPTS(31)        0
PI1             100 PI2             100 PI3              20
DTPHAS1       .0001 DTPHAS2        .001 DTPHAS3        .005
TEMP           75.0 PRESSUR       915.8 DENSITY      .00211
XPOS            0.0 YPOS            0.0 ZPOS          0.001
YAW             0.0 PITCH           0.0 ROLL            0.0
RVEL            0.0 QVEL            0.0 PVEL            0.0
WINDX         4.500 WINDY        -5.362 WINDZ           0.0
XACVEL        746.1 ZACVEL          0.0 CKPITHT         3.5
NPTSAAT           0
NPTSLAT           0
XPOSSRP        .165 YPOSSRP         0.0 ZPOSSRP         .55
XCGSA         .3625 YCGSA           0.0 ZCGSA        1.4000
IXXSA           4.0 IXYSA           0.0 IXZSA           0.0
IYYSA           5.0 IYZSA           0.0 IZZSA           1.0
PHISA           0.0 PSISA         -15.0 THESA           0.0
AREASA          6.0 HGHTSA          3.5 WGHTSA        167.0
XPOSBOT         0.0 YPOSBOT         0.0 ZPOSBOT         0.0
XPOSSCS         0.0 YPOSSCS         0.0 ZPOSSCS         0.0
XCGSO        0.7150 YCGSO           0.0 ZCGSO         .9683
IXXSO          22.0 IXYSO           0.0 IXZSO           0.0
IYYSO          22.0 IYZSO           0.0 IZZSO           6.3
AREASO          7.5 WGHTSO        341.2
AREAOAA         9.6 WGHTOAB       174.2 WGHTOAA       174.2
SOSEP         1.920 DMPGC          0.40
RAILNTH         3.5 RAILANG       -17.5
ISTRL             1 NSLBKS            0
KXSB        50000.0 KYSB         50000. MUSB          0.050
YKTOR         500.0
XPOSRRE         0.0 YPOSRRE      -.4167 ZPOSRRE         0.0
XPOSLRE         0.0 YPOSLRE       .4167 ZPOSLRE         0.0
INCAT             2
CATLNT(1)       3.5 CATSTK(1)       3.5 TCI(1)       0.0192
XPOSAP(1)       0.0 YPOSAP(1)    -.4167 ZPOSAP(1)       3.5
NPTSCT(1)         4
                0.0                 0.0                0.01           2450.0
               0.16              2450.0                0.20              0.0
CATLNT(2)       3.5 CATSTK(2)       3.5 TCI(2)       0.0192
XPOSAP(2)       0.0 YPOSAP(2)     .4167 ZPOSAP(2)       3.5
NPTSCT(2)         4
                0.0                 0.0                0.01           2450.0
               0.16              2450.0                0.20              0.0
ITUBEND           0
INRKT             2
RKIGN(1)        0.0 RKWGHT(1)       6.0 RKBURN(1)     0.236 RKDELY(1)    0.179
XPOSRK(1)       0.0 YPOSRK(1)   -0.5833 ZPOSRK(1)   -0.0533
RKALPH(1)     53.15 RKBETA(1)      68.0 RKGAMA(1)      45.0
RKNPTS(1)         7
                0.0                 0.0                0.02           2000.0
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               0.03                2200.0                 0.25               2400.0
               0.27                 300.0                 0.29                 10.0
               0.31                   0.0
RKIGN(2)        0.0 RKWGHT(2)         6.0 RKBURN(2)      0.238 RKDELY(2)      0.179
XPOSRK(2)       0.0 YPOSRK(2)      0.5833 ZPOSRK(2)    -0.0533
RKALPH(2)     53.15 RKBETA(2)       112.0 RKGAMA(2)       45.0
RKNPTS(2)         7
                0.0                   0.0                 0.02               2000.0
               0.03                2200.0                 0.25               2400.0
               0.27                 300.0                 0.29                 10.0
               0.31                   0.0
IDROGUE           1
TDDPLOY       0.155 DISPLOY          0.00 DROGLL         14.00
DRDRAG1        0.60 DROGPD1          3.25 POROSD1         0.05
AREADC         0.50 WGHTDC           3.00 CDCC            1.00
XDROGAP        0.00 YDROGAP          0.00 ZDROGAP         2.00
IDROGLS           1
NPTSDLS           2
               0.00                 0.039              1500.00                0.039
IFTDRO1           1
NPTDFT1           2
               0.00                 0.092              1500.00                0.092
IRECOV            1
RECOVLL        25.5 RECDRAG          0.75
RECOVPD       28.00 POROSR           0.05
XRECAP       0.2917 YRECAP           0.00 ZRECAP          3.083
CHALT1      7000.00 CHALT2       14000.00 GLIMIT          0.00
TDELAY         .000
NPTSROT           1
TRDPLOY       1.417
NPTSRLS           2
               0.00                 0.268                1500.                0.268
IPTRECV           1
NPTSRFT           2
               0.00                 0.983                1500.                0.983
IDART             1
DRTFRCE       900.0 DRTSTRT           8.0 DRTSTOP         21.0
 XDRTAP(1)   0.0417 YDRTAP(1)     -0.4167 ZDRTAP(1)    -0.1917
 XDRTCP(1)   0.6667 YDRTCP(1)     -0.4167 ZDRTCP(1)    -1.6900
 XDRTAP(2)   0.0417 YDRTAP(2)      0.4167 ZDRTCP(2)    -0.1916
 XDRTCP(2)   0.6667 YDRTCP(2)      0.4167 ZDRTCP(2)    -1.6900
ITVC              0
IDYNCG            1
STOP
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START
GESS PROGRAM VALIDATION - RUN NO. 3 - 28 MARCH 1983
SIIIS-ER A-7 DVT #2 - 200 KEAS - 98% OCCUPANT - LOW SPEED MODE
STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TSTART          0.0 TSTOP           0.0 ESTOP            30 IRESTRT          0
IUNITS            1 ISEATTR           0 ISOSEP            1 IPLOT            1
IDRIFLG           1
IREPTS( 1)        1 IREPTS( 2)        1 IREPTS( 3)        0 IREPTS( 4)       1
IREPTS( 5)        0 IREPTS( 6)        0 IREPTS( 7)        0 IREPTS( 8)       0
IREPTS( 9)        0 IREPTS(10)        0 IREPTS(11)        0 IREPTS(12)       0
IREPTS(13)        0 IREPTS(14)        0 IREPTS(15)        0 IREPTS(16)       0
IREPTS(17)        0 IREPTS(18)        0 IREPTS(19)        0 IREPTS(20)       0
IREPTS(21)        0 IREPTS(22)        0 IREPTS(23)        0 IREPTS(24)       0
IREPTS(25)        0 IREPTS(26)        0 IREPTS(27)        0 IREPTS(28)       0
IREPTS(29)        0 IREPTS(30)        0 IREPTS(31)        0
PI1             100 PI2             100 PI3              20
DTPHAS1       .0001 DTPHAS2        .001 DTPHAS3        .005
TEMP           59.0 PRESSUR       912.4 DENSITY      .00216
XPOS            0.0 YPOS            0.0 ZPOS          0.001
YAW             0.0 PITCH           0.0 ROLL            0.0
RVEL            0.0 QVEL            0.0 PVEL            0.0
WINDX       -18.966 WINDY        10.950 WINDZ           0.0
XACVEL        339.3 ZACVEL          0.0 CKPITHT         3.5
NPTSAAT           0
NPTSLAT           0
XPOSSRP        .165 YPOSSRP         0.0 ZPOSSRP         .55
XCGSA         .3825 YCGSA           0.0 ZCGSA        1.4000
IXXSA           4.0 IXYSA           0.0 IXZSA           0.0
IYYSA           5.0 IYZSA           0.0 IZZSA           1.0
PHISA           0.0 PSISA         -15.0 THESA           0.0
AREASA          6.0 HGHTSA          3.5 WGHTSA        163.0
XPOSBOT         0.0 YPOSBOT         0.0 ZPOSBOT         0.0
XPOSSCS         0.0 YPOSSCS         0.0 ZPOSSCS         0.0
XCGSO        0.8517 YCGSO           0.0 ZCGSO         1.036
IXXSO          22.0 IXYSO           0.0 IXZSO           0.0
IYYSO          22.0 IYZSO           0.0 IZZSO           6.3
AREASO          7.5 WGHTSO        418.5
AREAOAA         9.6 WGHTOAB       255.5 WGHTOAA       255.5
SOSEP         0.768 DMPGC          0.40
RAILNTH         3.5 RAILANG       -17.5
ISTRL             1 NSLBKS            0
KXSB        50000.0 KYSB         50000. MUSB          0.050
XKTOR         500.0
XPOSRRE         0.0 YPOSRRE      -.4167 ZPOSRRE         0.0
XPOSLRE         0.0 YPOSLRE       .4167 ZPOSLRE         0.0
INCAT             2
CATLNT(1)       3.5 CATSTK(1)       3.5 TCI(1)       0.0252
XPOSAP(1)       0.0 YPOSAP(1)    -.4167 ZPOSAP(1)       3.5
NPTSCT(1)         4
                0.0                 0.0                0.01           2450.0
               0.16              2450.0                0.20              0.0
CATLNT(2)       3.5 CATSTK(2)       3.5 TCI(2)       0.0252
XPOSAP(2)       0.0 YPOSAP(2)     .4167 ZPOSAP(2)       3.5
NPTSCT(2)         4
                0.0                 0.0                0.01           2450.0
               0.16              2450.0                0.20              0.0
ITUBEND           0
INRKT             2
RKIGN(1)        0.0 RKWGHT(1)       6.0 RKBURN(1)     0.248 RKDELY(1)    0.188
XPOSRK(1)       0.0 YPOSRK(1)   -0.5833 ZPOSRK(1)   -0.0533
RKALPH(1)     53.15 RKBETA(1)      68.0 RKGAMA(1)      45.0
RKNPTS(1)         7
                0.0                 0.0                0.02           2000.0
```

```
             0.03              2200.0               0.25                2400.0
             0.27               300.0               0.29                  10.0
             0.31                 0.0
RKIGN(2)      0.0 RKWGHT(2)       6.0 RKBURN(2)     0.248 RKDELY(2)      0.188
XPOSRK(2)     0.0 YPOSRK(2)    0.5833 ZPOSRK(2)   -0.0533
RKALPH(2)   53.15 RKBETA(2)     112.0 RKGAMA(2)      45.0
RKNPTS(2)       7
              0.0                 0.0               0.02                2000.0
             0.03              2200.0               0.25                2400.0
             0.27               300.0               0.29                  10.0
             0.31                 0.0
IDROGUE         1
TDDPLOY     0.158 DISPLOY        0.00 DROGLL        14.00
DRDRAG1      0.60 DROGPD1        3.25 POROSD1        0.05
AREADC       0.50 WGHTDC         3.00 CDCC           1.00
XDROGAP      0.00 YDROGAP        0.00 ZDROGAP        2.00
IDROGLS         1
NPTSDLS         2
             0.00               0.071            1500.00                 0.071
IFTDRO1         1
NPTDFT1         2
             0.00               0.165            1500.00                 0.165
IRECOV          1
RECOVLL      25.5 RECDRAG        0.75
RECOVPD     28.00 POROSR         0.05
XRECAP     0.2917 YRECAP         0.00 ZRECAP        3.083
CHALT1    7000.00 CHALT2     14000.00 GLIMIT         0.00
TDELAY       .000
NPTSRDT         1
TRDPLOY     0.333
NPTSRLS         2
             0.00               0.248              1500.                 0.248
IFTRECV         1
NPTSRFT         2
             0.00               0.991              1500.                 0.991
IDART           1
DRTFRCE     900.0 DRTSTRT         8.0 DRTSTOP        21.0
  XDRTAP(1) 0.0417 YDRTAP(1)  -0.4167 ZDRTAP(1)   -0.1917
  XDRTCP(1) 0.6667 YDRTCP(1)  -0.4167 ZDRTCP(1)   -1.6900
  XDRTAP(2) 0.0417 YDRTAP(2)   0.4167 ZDRTCP(2)   -0.1916
  XDRTCP(2) 0.6667 YDRTCP(2)   0.4167 ZDRTCP(2)   -1.6900
ITVC            0
IDYNCG          1
STOP
```

```
START
GESS PROGRAM VALIDATION - RUN NO. 4 - 28 MARCH 1983
SIIIS-ER A-7 DVT #1 - 0.0 KEAS - 3% OCCUPANT - LOW SPEED MODE
STENCEL SEAT - CATAPULT,ROCKET,DART,DROGUE,CHUTE OPERATE
TSTART           0.0 TSTOP          0.0 ESTOP          30 IRESTRT          0
IUNITS             1 ISEATTR          0 ISOSEP          1 IPLOT            1
IDRIFLG            1
IREPTS( 1)         1 IREPTS( 2)       1 IREPTS( 3)      0 IREPTS( 4)       1
IREPTS( 5)         0 IREPTS( 6)       0 IREPTS( 7)      0 IREPTS( 8)       0
IREPTS( 9)         0 IREPTS(10)       0 IREPTS(11)      0 IREPTS(12)       0
IREPTS(13)         0 IREPTS(14)       0 IREPTS(15)      0 IREPTS(16)       0
IREPTS(17)         0 IREPTS(18)       0 IREPTS(19)      0 IREPTS(20)       0
IREPTS(21)         0 IREPTS(22)       0 IREPTS(23)      0 IREPTS(24)       0
IREPTS(25)         0 IREPTS(26)       0 IREPTS(27)      0 IREPTS(28)       0
IREPTS(29)         0 IREPTS(30)       0 IREPTS(31)      0
PI1              100 PI2            100 PI3            20
DTPHAS1        .0001 DTPHAS2       .001 DTPHAS3      .005
TEMP            56.0 PRESSUR      919.1 DENSITY    .00219
XPOS             0.0 YPOS           0.0 ZPOS        0.001
YAW              0.0 PITCH          0.0 ROLL          0.0
RVEL             0.0 QVEL           0.0 PVEL          0.0
WINDX         -23.24 WINDY       -4.098 WINDZ         0.0
XACVEL           0.0 ZACVEL         0.0 CKPITHT       3.5
NPTSAAT            0
NPTSLAT            0
XPOSSRP         .165 YPOSSRP        0.0 ZPOSSRP       .55
XCGSA          .3625 YCGSA          0.0 ZCGSA      1.4000
IXXSA            4.0 IXYSA          0.0 IXZSA         0.0
IYYSA            5.0 IYZSA          0.0 IZZSA         1.0
PHISA            0.0 PSISA        -15.0 THESA         0.0
AREASA           6.0 HGHTSA         3.5 WGHTSA      164.0
XPOSBOT          0.0 YPOSBOT        0.0 ZPOSBOT       0.0
XPOSSCS          0.0 YPOSSCS        0.0 ZPOSSCS       0.0
XCGSO         0.7142 YCGSO          0.0 ZCGSO       .9558
IXXSO           22.0 IXYSO          0.0 IXZSO         0.0
IYYSO           22.0 IYZSO          0.0 IZZSO         6.3
AREASO           7.5 WGHTSO       333.0
AREAOAA          9.6 WGHTOAB      169.0 WGHTOAA     169.0
SOSEP          2.484 DMPGC         0.40
RAILNTH          3.5 RAILANG      -17.5
ISTRL              1 NSLBKS           0
KXSB         50000.0 KYSB        50000. MUSB        0.050
YKTOR          500.0
XPOSRRE          0.0 YPOSRRE      -.4167 ZPOSRRE      0.0
XPOSLRE          0.0 YPOSLRE       .4167 ZPOSLRE      0.0
INCAT              2
CATLNT(1)        3.5 CATSTK(1)      3.5 TCI(1)     0.0172
XPOSAP(1)        0.0 YPOSAP(1)    -.4167 ZPOSAP(1)    3.5
NPTSCT(1)          4
                 0.0                0.0              0.01           2450.0
                0.16             2450.0              0.20              0.0
CATLNT(2)        3.5 CATSTK(2)      3.5 TCI(2)     0.0172
XPOSAP(2)        0.0 YPOSAP(2)     .4167 ZPOSAP(2)    3.5
NPTSCT(2)          4
                 0.0                0.0              0.01           2450.0
                0.16             2450.0              0.20              0.0
ITUBEND            0
INRKT              2
RKIGN(1)         0.0 RKWGHT(1)      6.0 RKBURN(1)   0.247 RKDELY(1)    0.180
XPOSRK(1)        0.0 YPOSRK(1)  -0.5833 ZPOSRK(1) -0.0533
RKALPH(1)      53.15 RKBETA(1)     68.0 RKGAMA(1)    45.0
RKNPTS(1)          7
                 0.0                0.0              0.02           2000.0
```

```
                0.03               2200.0                  0.25               2400.0
                0.27                300.0                  0.29                 10.0
                0.31                  0.0
RKIGN(2)         0.0 RKWGHT(2)        6.0 RKBURN(2)        0.247 RKDELY(2)      0.180
XPOSRK(2)        0.0 YPOSRK(2)     0.5833 ZPOSRK(2)      -0.0533
RKALPH(2)      53.15 RKBETA(2)      112.0 RKGAMA(2)         45.0
RKNPTS(2)          7
                 0.0                  0.0                 0.02               2000.0
                0.03               2200.0                 0.25               2400.0
                0.27                300.0                 0.29                 10.0
                0.31                  0.0
IDROGUE            1
TDDPLOY        0.148 DISPLOY         0.00 DROGLL           14.00
DRDRAG1         0.60 DROGPD1         3.25 POROSD1           0.05
AREADC          0.50 WGHTDC          3.00 CDCO              1.00
XDROGAP         0.00 YDROGAP         0.00 ZDROGAP           2.00
IDROGLS            1
NPTSDLS            2
                0.00                0.144              1500.00                0.144
IFTDRO1            1
NPTDFT1            2
                0.00                0.337              1500.00                0.337
IRECOV             1
RECOVLL         25.5 RECDRAG         0.75
RECOVPD        28.00 POROSR          0.05
XRECAP        0.2917 YRECAP          0.00 ZRECAP           3.083
CHALT1       7000.00 CHALT2      14000.00 GLIMIT            0.00
TDELAY          .000
NPTSRDT            1
TRDPLOY        1.585
NPTSRLS            2
                0.00                0.513                1500.                0.513
IFTRECV            1
NPTSRFT            2
                0.00                1.662                1500.                1.662
IDART              1
DRTFRCE        900.0 DRTSTRT          8.0 DRTSTOP           21.0
  XDRTAP(1)   0.0417 YDRTAP(1)    -0.4167 ZDRTAP(1)      -0.1917
  XDRTCP(1)   0.6667 YDRTCP(1)    -0.4167 ZDRTCP(1)      -1.6900
  XDRTAP(2)   0.0417 YDRTAP(2)     0.4167 ZDRTCP(2)      -0.1916
  XDRTCP(2)   0.6667 YDRTCP(2)     0.4167 ZDRTCP(2)      -1.6900
ITVC               0
IDYNCG             1
STOP
```

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